HUMAN ANATOMY FOR ARTISTS

THE ELEMENTS OF FORM

ELIOT GOLDFINGER

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To my son Gary, for his exquisite display of anatomy in its smaller scale, I am lovingly grateful. And finally, to my wife, Louise Edeiken, I offer my love and most affectionate thanks for her support, encouragement, participation, and "great expressions."

Introduction

This book is a *reference guide* to the anatomy of the human body, *specifically designed for the artist*. All the anatomical structures that create or influence surface form are included in this comprehensive work and are individually illustrated and described in great detail. Most importantly, this book is intended for use by artists on all levels—from the beginning student to the experienced professional. The layout is designed so that a great deal of information about each structure is immediately available in one place; the reader selectively uses only that which is needed at the moment. As one's understanding of anatomy increases, further study can be made into the text, illustrations, and diagrams. By its use of numerous illustrated views, cross sections, sculptural models, and verbal descriptions, *Human Anatomy for Artists* offers a three-dimensional understanding of a three-dimensional subject.

The subject of anatomy can be divided into many fields of study. **Artistic anatomy,** which is dealt with exclusively here, is a very specialized discipline. It is the *science of form*—what creates it, and what influences it. Much information that has no bearing on surface form has been omitted. Those structures that are involved in the creation of surface form are described in great depth. For the most part, the terminology used is the current scientific usage. Older, outdated terms are included for those familiar with them, and a few new terms have been invented (when needed) as an aid to efficient communication.

Although variation is the rule in nature, the information in this book—drawings, photographs, text, and sculptural models—has been oriented toward the *classic* or *ideal* adult male configuration. Texture and minute detail have been avoided in favor of strong, clear form. Important common variations within the norm are described. Comparisons with the female, the elderly, and the young are made when appropriate. The photographs of the live models and their adjacent muscle illustrations are not necessarily coordinated in terms of pose or exact muscle configurations—the drawings are idealized; the models, of course, are individuals. Almost all the drawings are in the anatomical position; however, in order to cause a muscle to "pop" while photographing it, models were sometimes placed in poses other than the anatomical position. Additional descriptions, photographs, and/or drawings are provided when a muscle changes its shape radically in different poses. Simplified diagrams are used to capture the essence of a structure. Throughout the book, the structures of the right side of the body are illustrated.

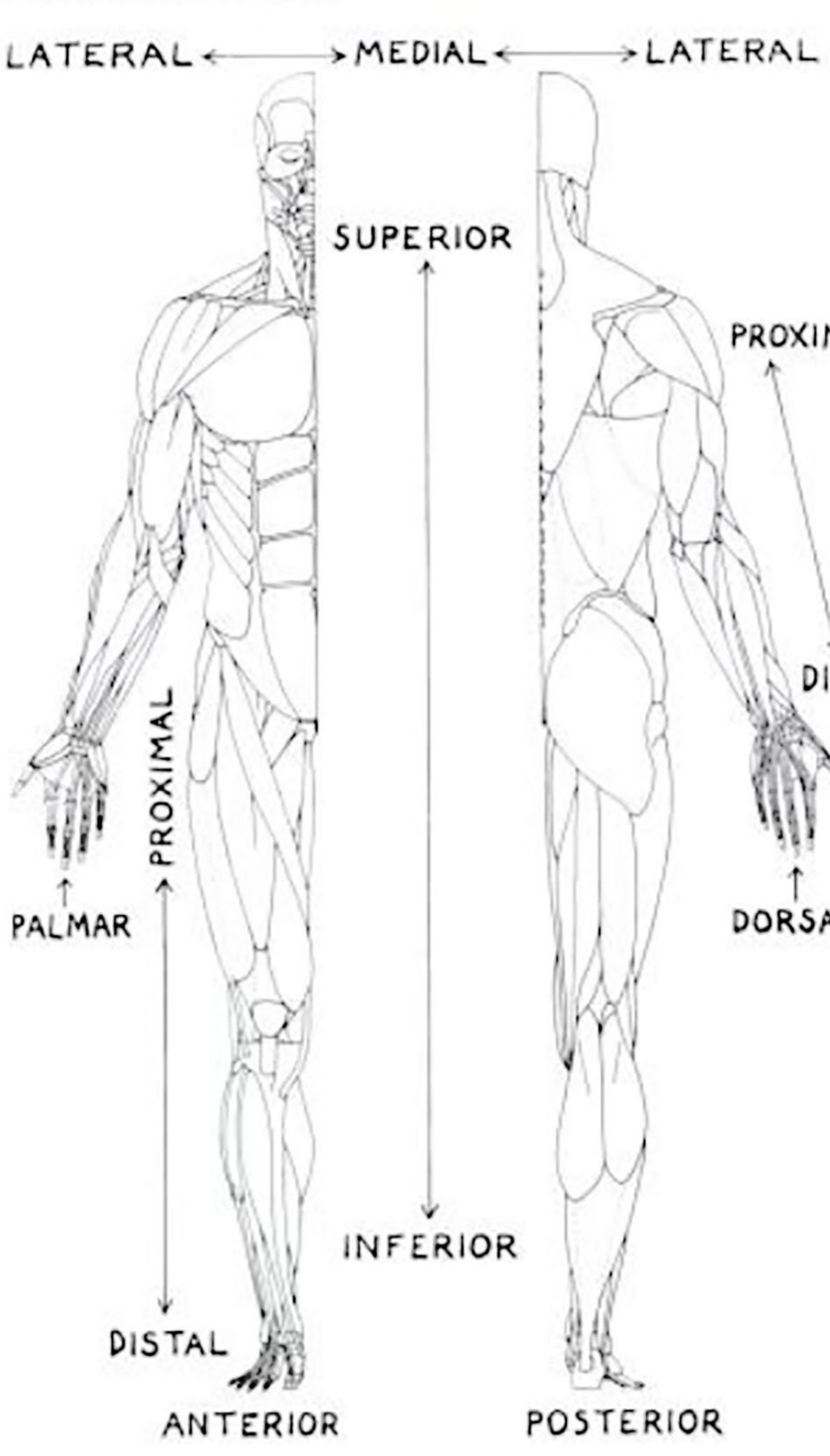
This book endeavors to analyze one complex system in nature—the human body. It concentrates on two basic opposing concepts: study of the *parts* and study of the *whole*. The *parts* are the anatomical components of the body—bones, joints, muscles, skin, fat, veins, etc. The *whole* is a singular conception for a total figure. It involves the assemblage and consolidation of the numerous anatomical units

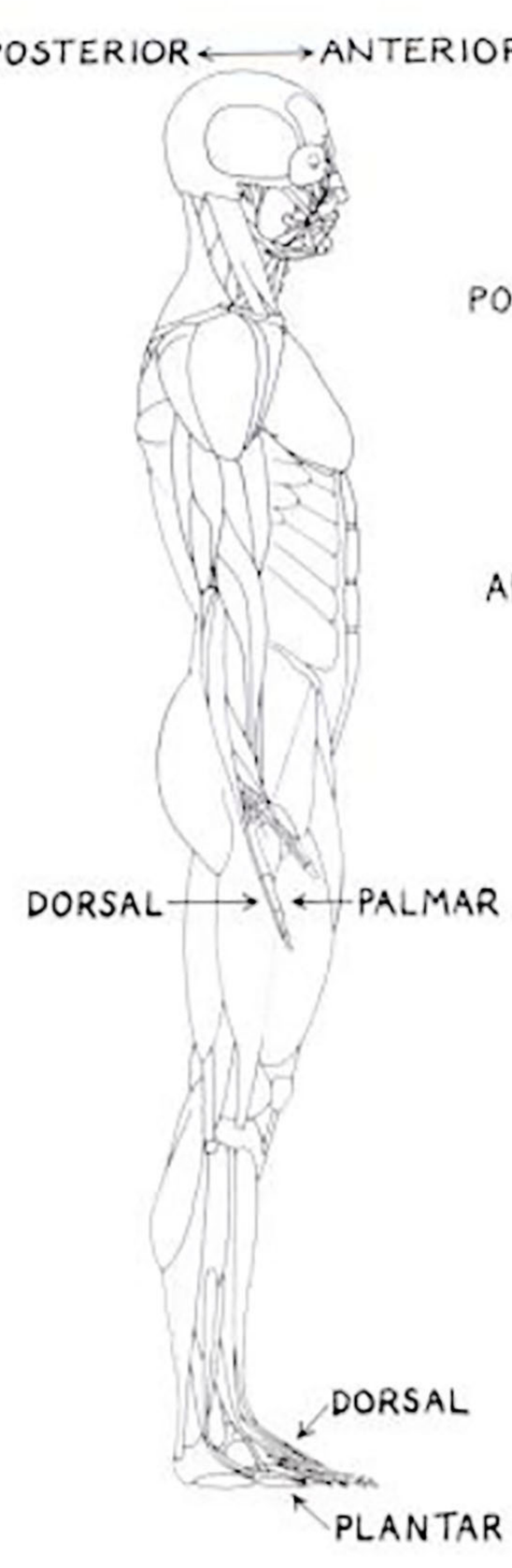
into a simple volumetric statement, or **mass conception.** The anatomical descriptions are scientific and objective; the mass conceptions are subjective, as they must be, and are here offered as suggestions or starting points for one's development of a personal conception of the figure. Each mass conception is but one of many ways to visualize the figure. The artistic expression of the figure must be based on decision through knowledge.

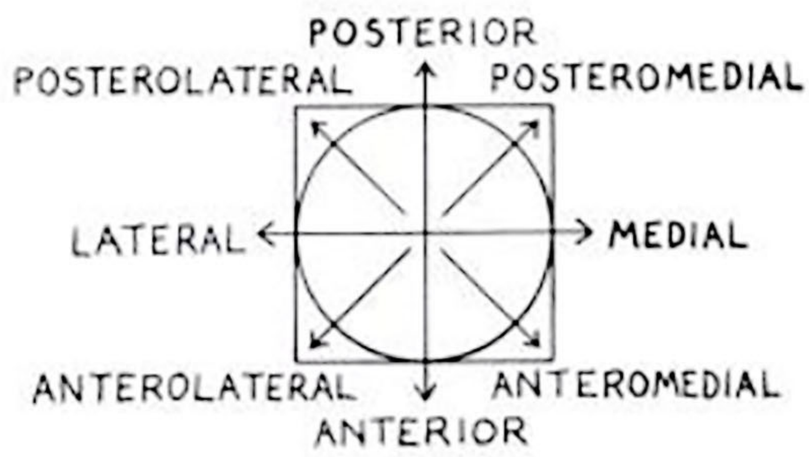
Except for the section dealing with proportion, all the illustrations are by the author.

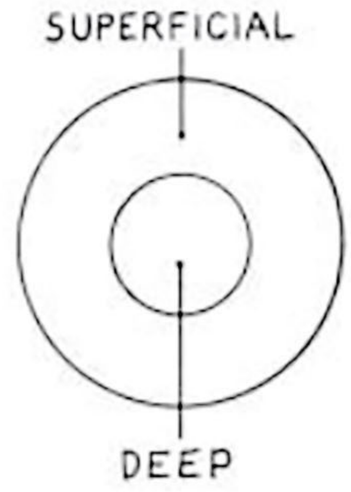
New York E. G.
October 1990

TERMINOLOGY









Terminology

The Anatomical Position the basic reference position of the figure, to which the terminology below is applied to describe the *relationship of one part to another*. In the anatomical position, the figure stands erect with feet together, arms down, and palms facing forward (the forearms are supinated). Also referred to as the **reference position** (see accompanying illustration on the facing page).

Anterior (Ventral) toward the front of the body.

Posterior (Dorsal) toward the back of the body. Dorsal also refers to the back of the hand and the top of the foot.

Superior (Cranial) toward the top; above.

Inferior (Caudal) toward the bottom; below.

Median located *on* the midline of the torso or the limbs.

Medial toward the midline, away from the side of the body.

Lateral away from the midline, toward the side of the body.

Internal deep; at one time synonymous with medial.

External superficial; at one time synonymous with lateral.

Proximal ("in close proximity") related to the limbs—toward the attachment of that limb to the body, i.e., near the trunk.

Distal ("distant") related to the limbs—away from the attachment of that limb to the body, i.e., away from the trunk.

Deep away from the surface, or covered by other structures.

Superficial toward or at the surface.

Subcutaneous just below the skin; related especially to bone (e.g., bony landmarks).

Major (Greater) larger in size.

Minor (Lesser) smaller in size.

Palmar (Volar) refers to the palm of the hand.

Plantar refers to the sole of the foot.

The Skeleton

The *SKELETON* is the internal framework of the body and is made up of **bones** and **cartilage.** The study of bones is called **osteology.** Bones provide *support* (when they are locked in position by the muscles and ligaments) and *protection* (the skull, rib cage, and pelvis protect their contents). They produce *motion*, acting as levers when pulled by the muscles. **Cartilage** is a hard, yet elastic (resilient) tissue. The costal, xiphoid, nasal, and ear cartilages, and the cartilages of the larynx, all directly create surface form.

Bones move against one another, or **articulate** with each other, at **joints.** Their articulating surfaces are covered with lubricated **articular cartilage.** Bones are held in their proper relationship to each other at the joints by strong, fibrous, nonelastic bands called **ligaments,** which keep them in contact yet permit normal motion. A ligament connects bone to bone (a tendon connects muscle to bone).

The bones are classified according to their shapes into the following categories: **long bones** (radius, femur, fibula, metacarpals, phalanges); **short bones** (carpals, tarsals, sesamoids); **flat bones** (cranial bones, ilium, scapula, ribs); and **irregular bones** (vertebrae, facial bones).

Long bones consist of an elongated **body** or **shaft** (straight or slightly curved) with an *expansion at either end.* Their articular surfaces are located at their ends. The expansion closer to the center of the body is called the **proximal extremity,** while the one further away is called the **distal extremity.** Sometimes the rounder, smaller, and more regular-shaped expansion is called the **head;** it can be located at either the proximal or the distal extremity. Large articular prominences are referred to as **condyles,** and upon these are found the smaller, nonarticular projecting **epicondyles.** Short bones have no shaft, and flat bones are curved plates.

Relating to bone, a **spine** is either a projecting point or a raised ridge; a **process** is a projecting extension of varying shape; and a **tuberosity** is an enlargement. A **fossa** is a shallow concave depression, and a **crest** is a high ridge. A **sesamoid bone** is a small rounded bone that is essentially embedded in the tendon of a muscle, often giving that tendon greater mechanical advantage by moving the tendon away from the joint beneath it. Sesamoid bones are found at the metacarpophalangeal joint of the thumb, the metatarsophalanageal joint of the big toe, and at the knee (the patella is the largest sesamoid bone of the body).

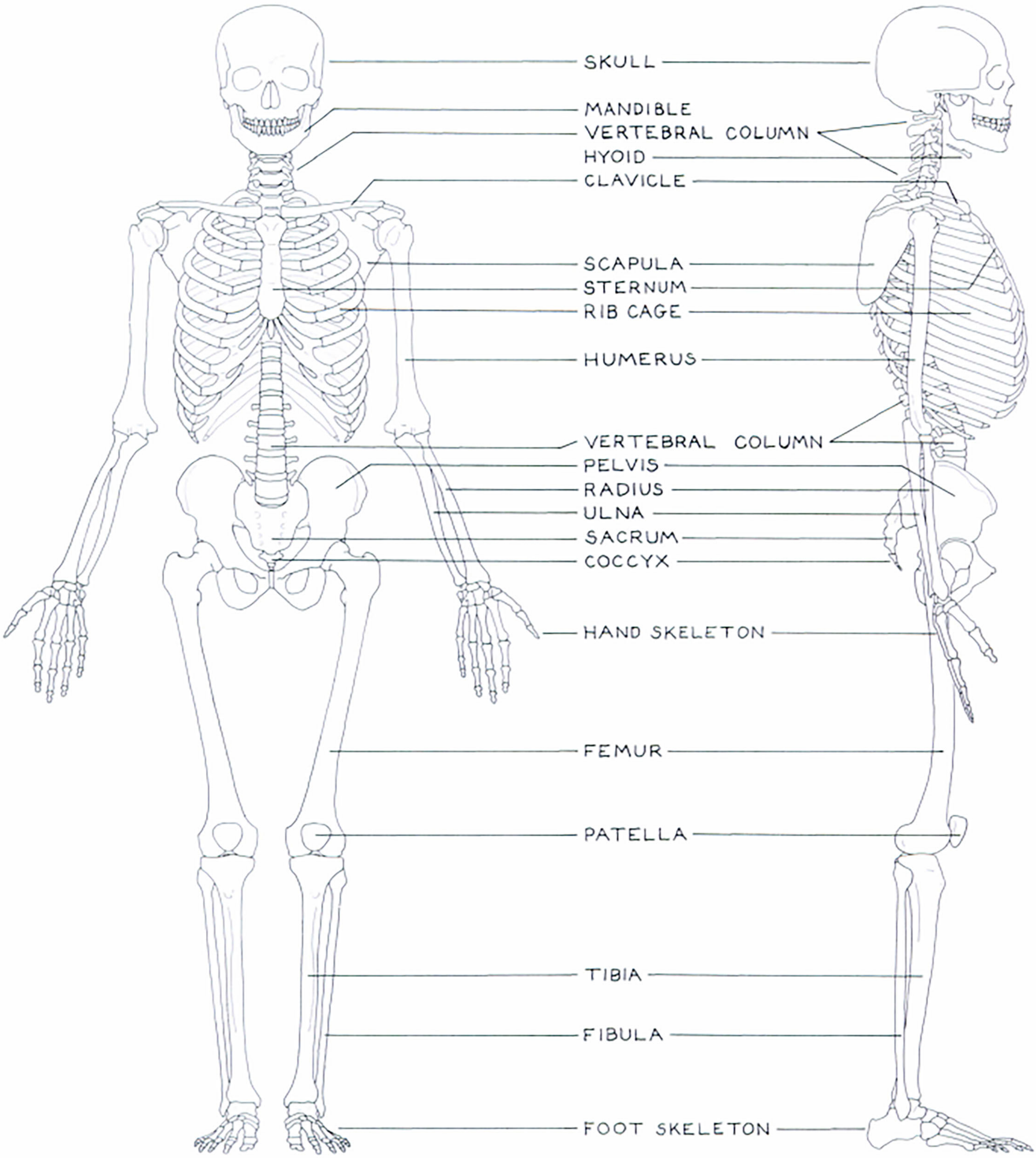
Bone may directly create surface form (elbow, forehead, medial surface of the tibia, clavicle), strongly influence it (rib cage, sacrum, back of hands and feet), or be concealed deep in muscle (shaft of fibula and humerus, cervical vertebrae). Areas of bone just below the skin are **subcutaneous.** Prominent subcutaneous points of bone are called **bony landmarks** and may serve as important proportional measuring points of the body. Locating the bony landmarks in life is the key to understanding the exact position of the entire skeleton, which for the most part is embedded in the soft tissues of the body. In muscular individuals, subcutaneous points and ridges may show up as depressions surrounded by bulging muscles. Bony landmarks surrounded by fat often appear as depressions or dimples. In thin individuals, these same bony areas may appear as raised ridges and points because of undeveloped musculature and lack of fat. The proportions of a figure are created by the relative lengths of the bones. Proportions are measured from bony landmarks, but can be measured from fleshy landmarks as well (e.g., nipple, navel).

An **interosseous membrane** is a membrane attached between the shafts of two bones. Two are found in the body—one in the forearm between the radius and the ulna and the other in the lower leg between the tibia and the fibula. Interosseous membranes connect bones and provide additional sites for muscle attachment.

The skeleton is subdivided into axial and appendicular skeletons. The **axial skeleton** consists of the skull, vertebrae, sacrum, coccyx, and rib cage. The **appendicular skeleton** consists of the arm bones and shoulder girdle and the leg bones and pelvis. The **shoulder girdle,** consisting of the scapula and clavicle, is characterized by its delicate structure and great range of motion, while the strong and stable **pelvic girdle** is made up of the bones of the pelvis and the sacrum, which are rigidly locked together. The bones of the leg, which function as weight-bearing columns, are stronger and heavier than the bones of the arm.

The artist must develop the ability to visualize the skeleton within the live model, for onto this internal scaffolding are attached the numerous convex forms of the musculature.

The Skeleton



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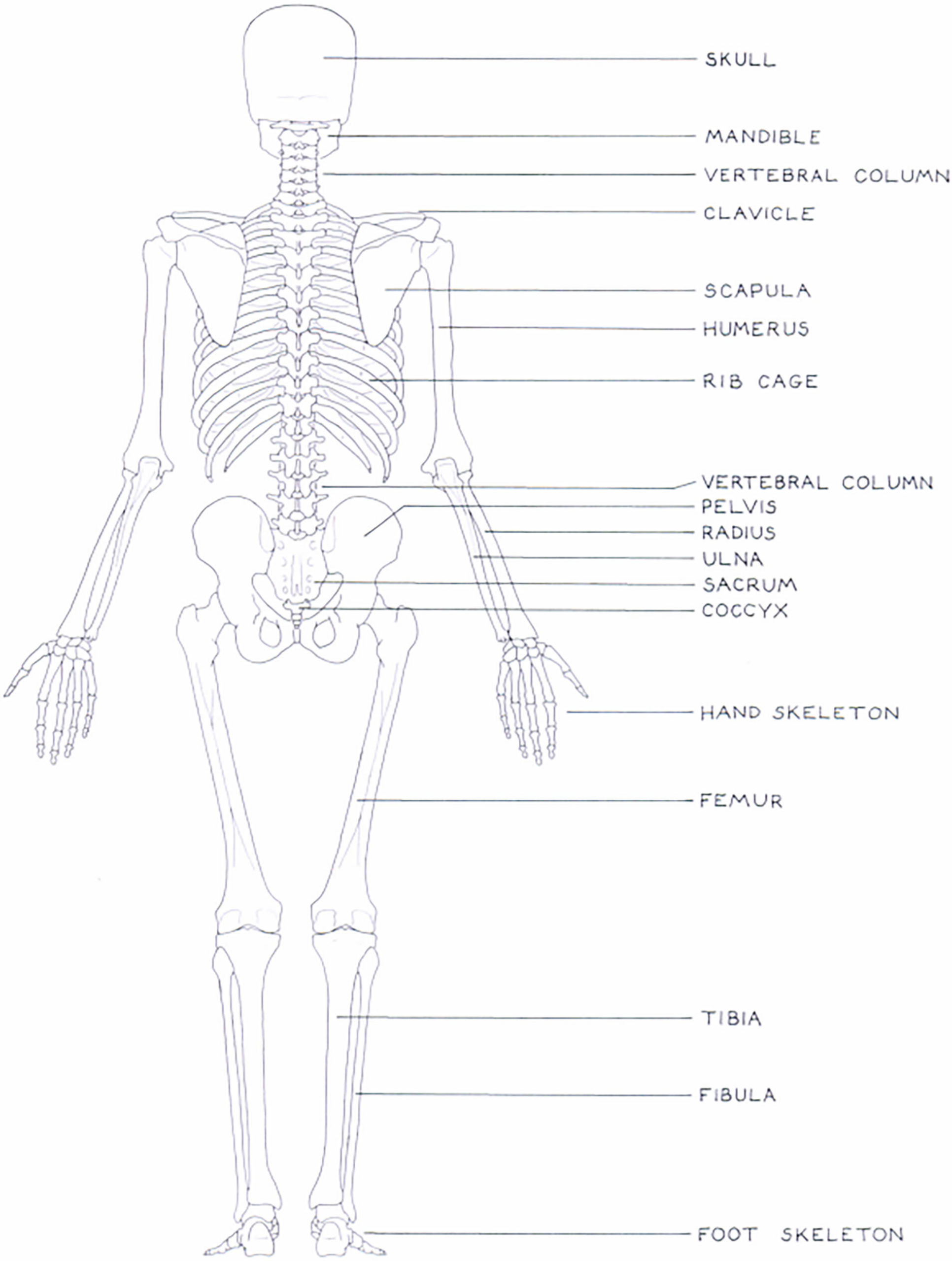
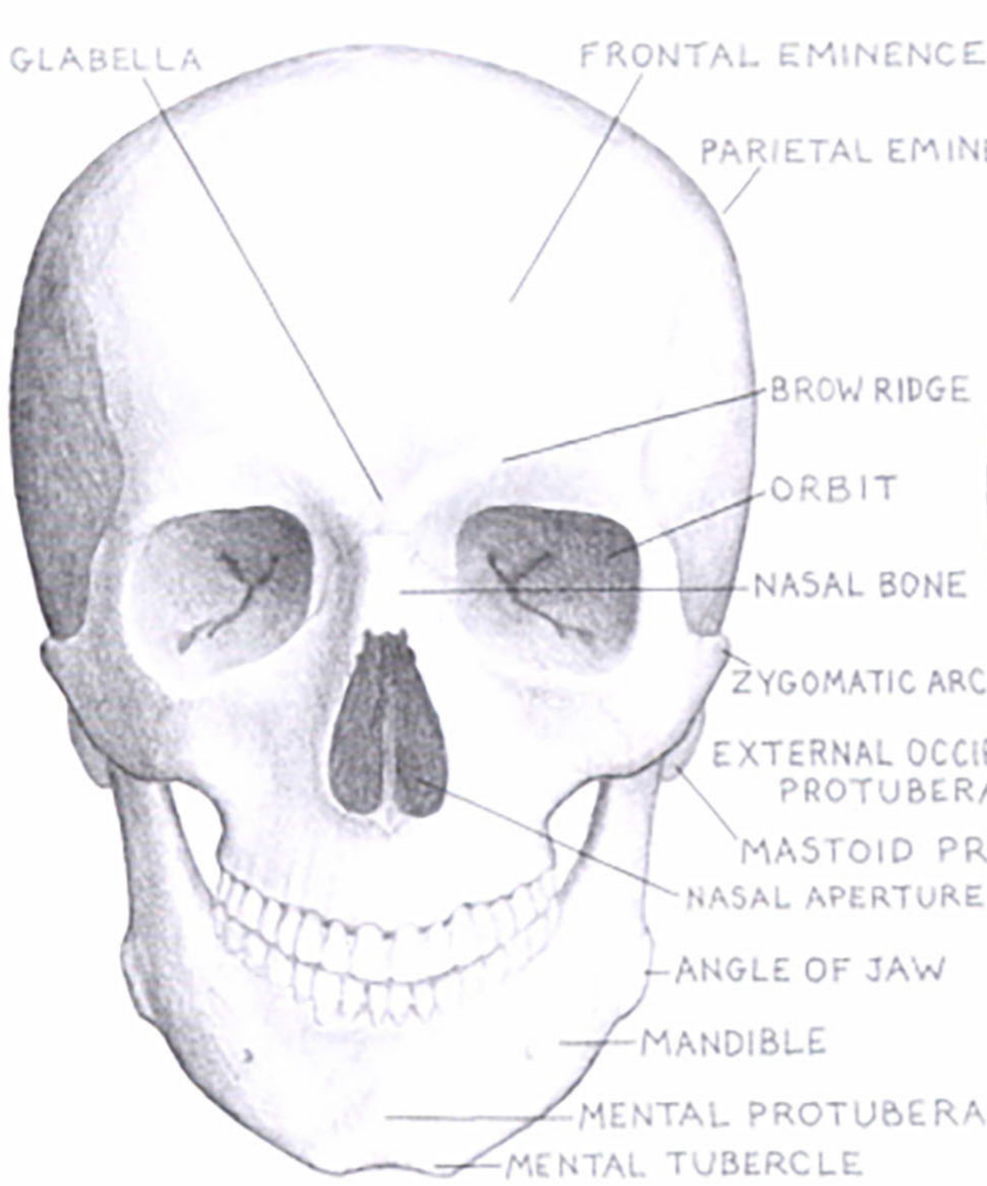
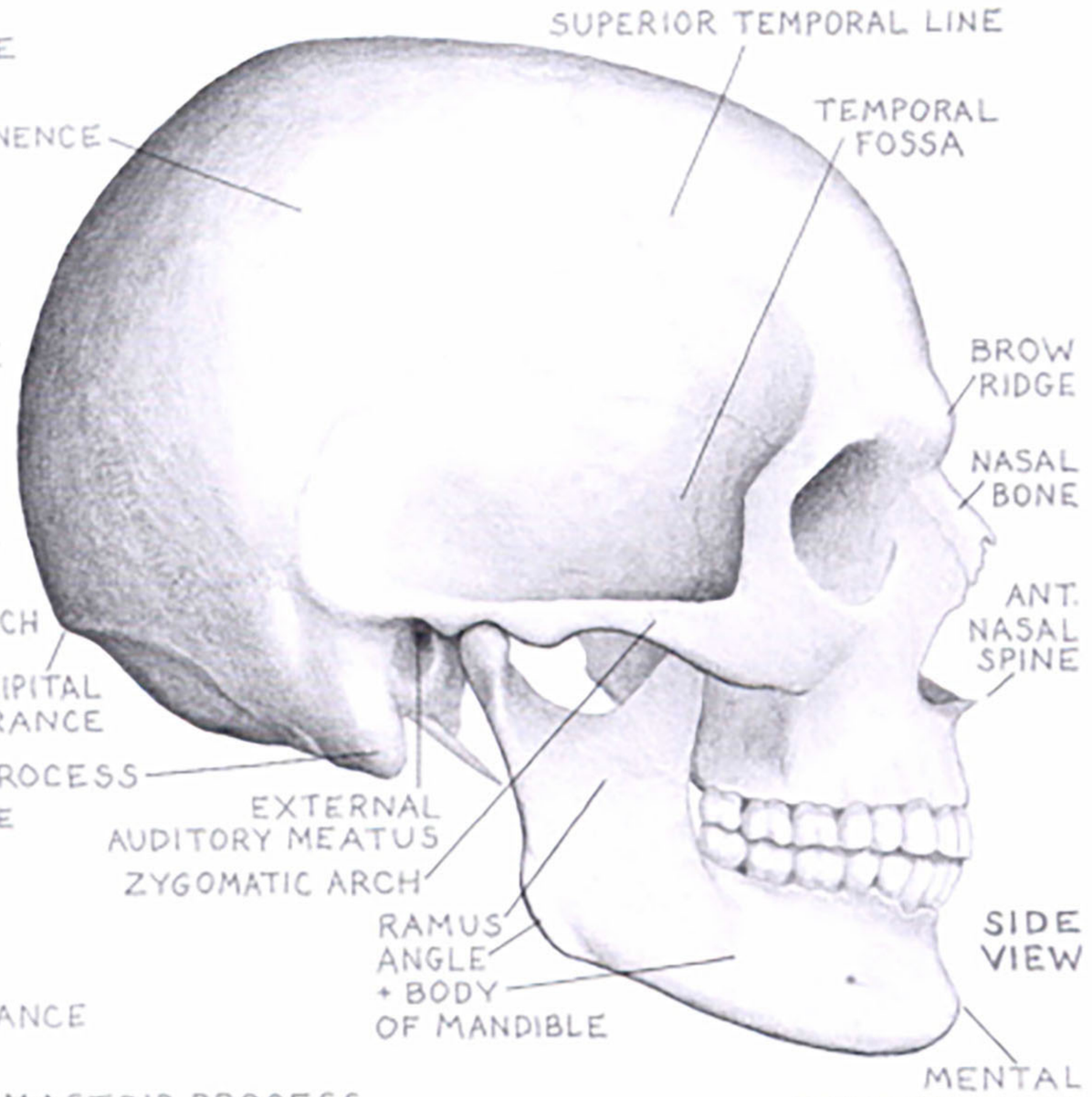
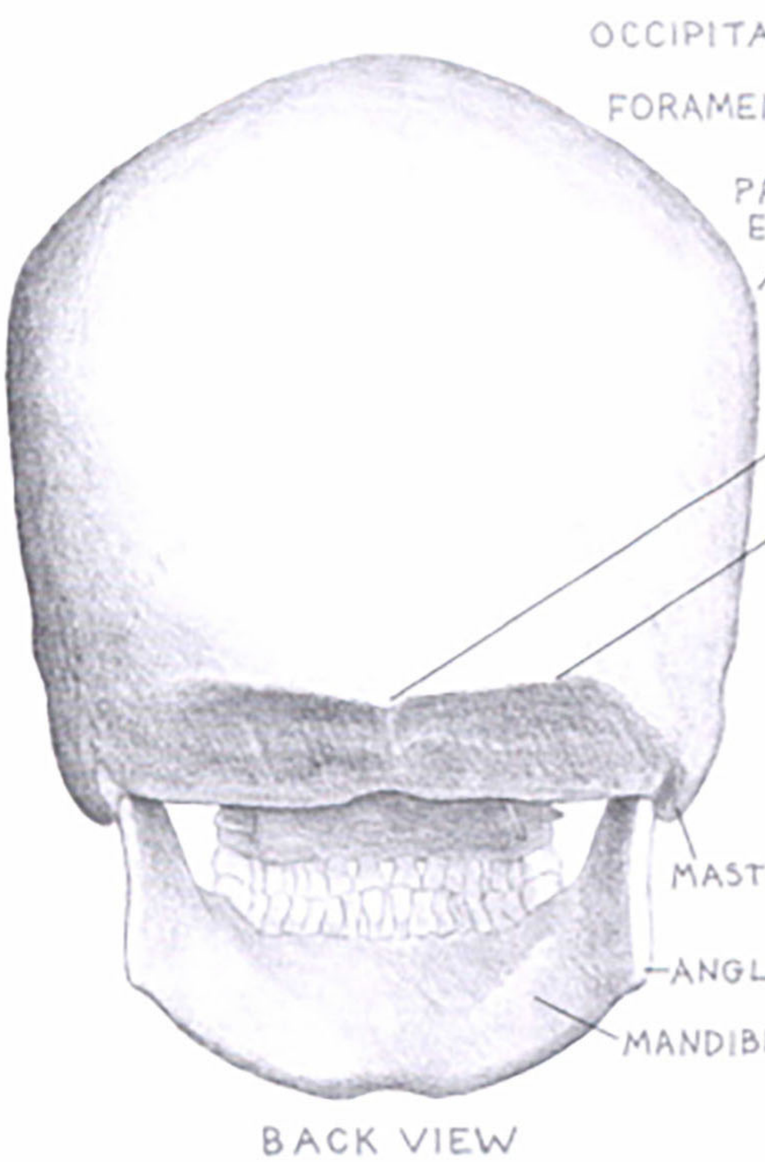




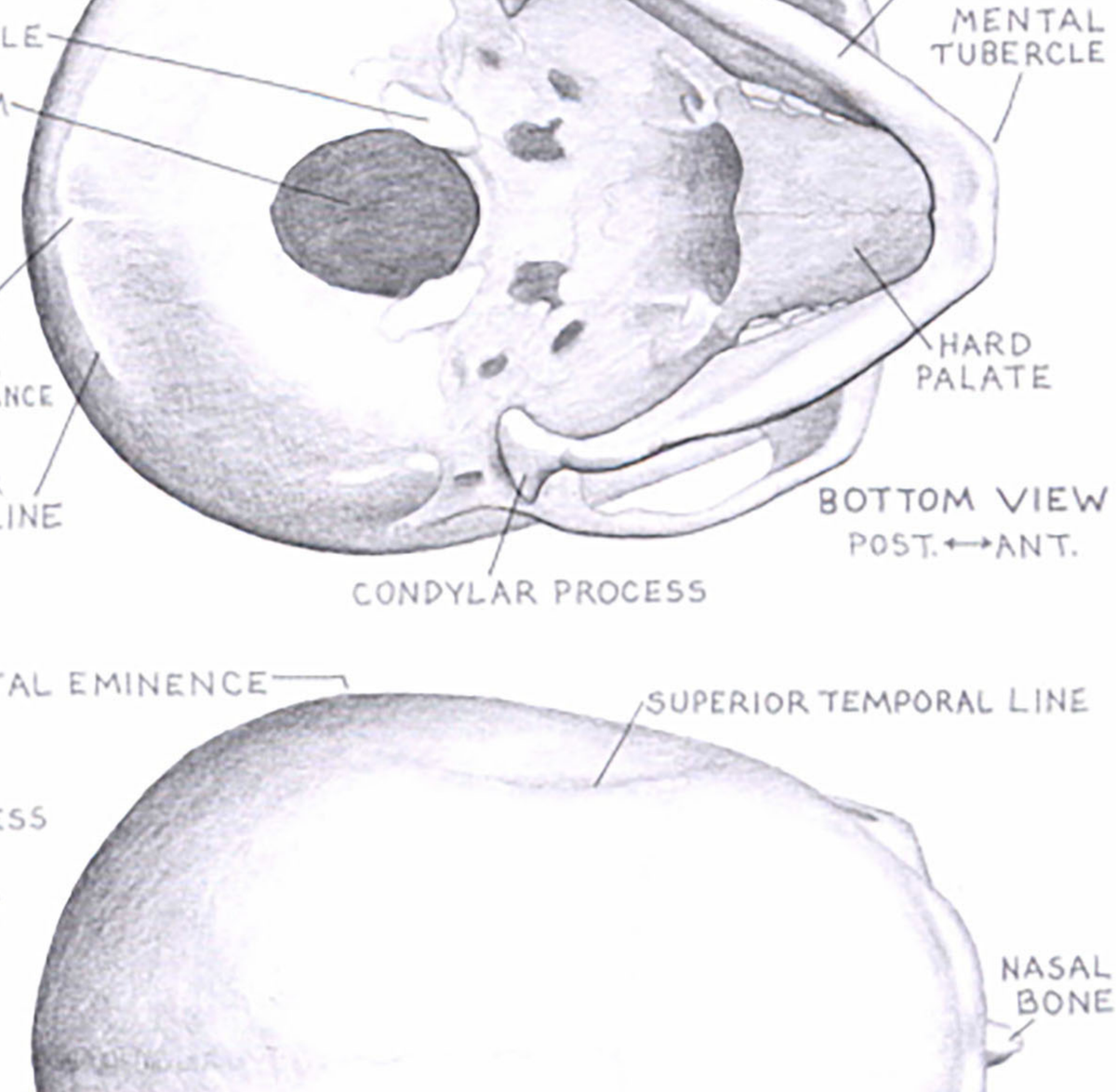
FRONT VIEW



SIDE VIEW



BACK VIEW



BOTTOM VIEW
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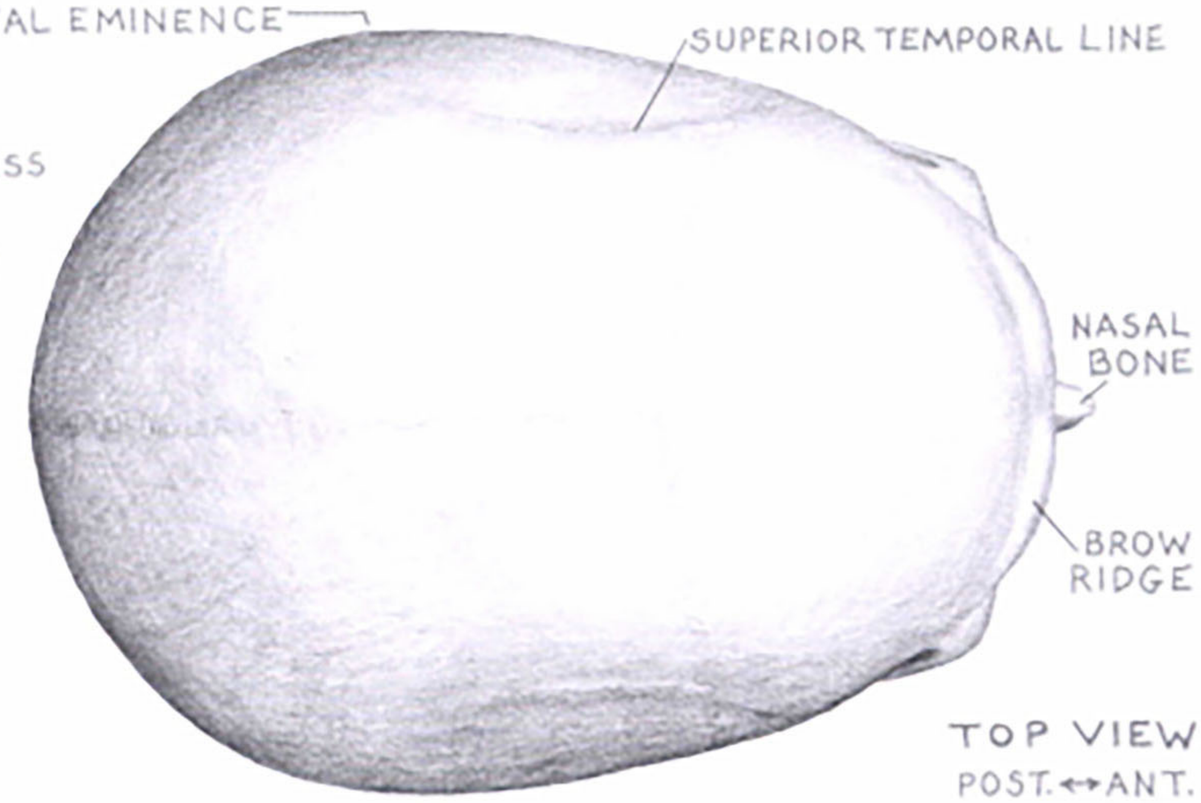

TOP VIEW
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The *SKULL* is the skeleton of the head; it is made up of the bones of the cranium, the face, and the lower jaw. The structure of the skull directly determines much of the shape of the head and face in life. Its numerous bones are held together at immovable joints called **sutures.** The only movable joint is the articulation of the lower jaw with the cranium.

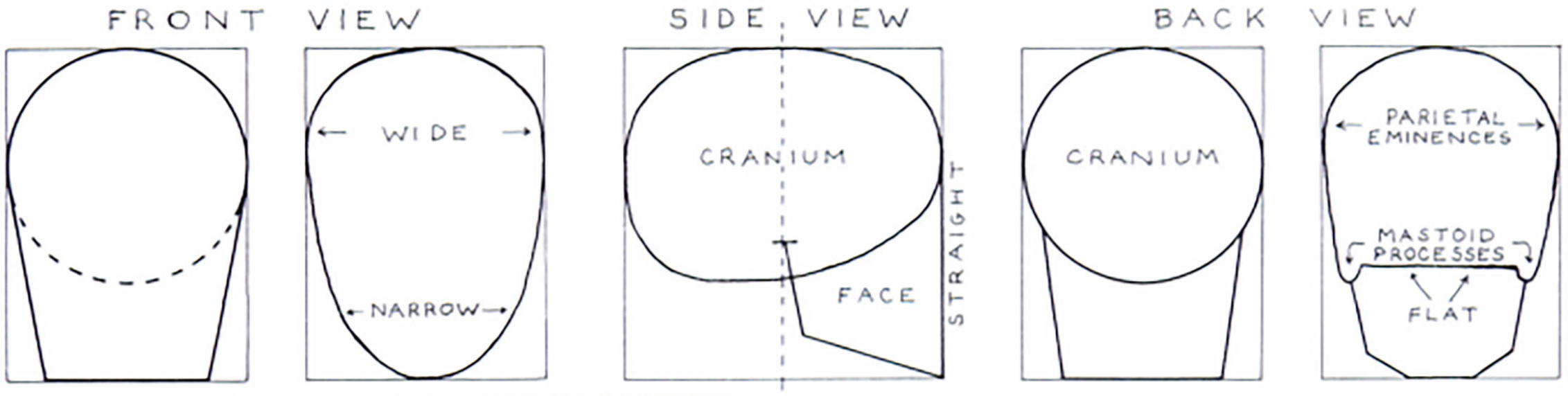
The *CRANIUM,* or braincase, is an ovoid container that houses the brain. It is elongated from front to back, varying from long and narrow to short and round in different individuals. It is narrow in front where it forms the forehead and becomes wider posteriorly. The **widest part** of the skull is either at the **parietal eminence** or somewhat below and anterior to this point. The widest part of the cranium is almost always wider than the zygomatic arches, which are the widest parts of the face. From the top view, the cranium appears egg-shaped; from the back view, its width and height are about equal.

The cranium is balanced directly over the vertebral column. The **foramen magnum,** the opening through which the brain connects with the spinal column, is located on the *bottom* of the base of the skull; this balance of the skull is a uniquely human characteristic. The elongated convex **occipital condyles,** located on either side of the foramen magnum, articulate with their corresponding concavities on the top of the first cervical vertebra, the **atlas.** The bottom of the cranium is located roughly at the level of the base of the nasal aperture.

The **external occipital protuberance** is a bony projection at the back of the base of the cranium where the neck meets the skull; it is easily palpated in life. The cylinder of the neck meets the base of the skull in back at the **superior nuchal line.**

The sides of the cranium are somewhat flattened, but still convex, and meet the upper front portion of the cranium at a ridge, the **superior temporal line.** This line is more pronounced anteriorly and can usually be seen on the surface of the head in life. It marks the junction of the bony skull with the temporalis muscle and forms the edge or plane change where the forehead's front plane meets the side plane. The depressed area on the side of the cranium—posterior to the bone of the orbit, above the zygomatic arch, and below the temporal line (in which the temporal muscle sits)—is called the **temporal fossa.** The temporalis muscle fills this depression.

The **mastoid process,** a large, inferiorly pointed conical projection, is located at the side of the base of the cranium, just posterior to the **external auditory** (acoustic) **meatus,** or **ear hole.** The mastoid process projects below the base of the cranium and is larger and more prominent in the male.



The **highest point** of the skull is usually located posterior to the midline of the skull in side view, directly above the mastoid process. Sometimes it is located more forward at the actual midline. The top profile of the cranium may be either rounded or straight, descending obliquely downward and forward. A wide transverse depression passing from side to side is sometimes found across the middle of the top of the skull. The forehead at the front of the cranium appears as a large single, simple, rounded bulge or shows two wide swellings, the **frontal eminences,** on either side of the midline. The female shows a rounder, more upright forehead.

The *FACIAL BONES* form the skeleton of the orbits of the eyes, the aperture of the nose, the cheekbones, and the upper jaw. With the mandible, the bones of the face, as a mass, hang down off the front portion of the cranium. The profile of the facial skeleton is basically straight and vertical, with the brow, nasal bones, muzzle, and chin variously projecting forward to different degrees, depending on sex, race, and age. A classical skull has a projecting forehead and a receding face.

The **eye sockets,** or **orbits,** are square holes with rounded corners, angled upward and medially. The outer border is posterior to the inner border (see side view). The bony ridge of the upper outer corner of the orbit is an important surface landmark and is located where the front and side planes of the face meet. The eyebrow sits on the upper border of the orbit.

The frontal sinuses form the **superciliary arches** (or superciliary crests). Located on either side of the midline above the orbits, they touch on the midline. They are commonly called the **brow ridges** and are more prominent in men than in women, often being absent in the latter. Because of their forward projection, they make the forehead of the male skull appear more sloping than the upright female forehead. The brow ridges are crescent-shaped and thicker medially. Together they form a wide raised V above the top of the nose.

The **glabella** is the slight depression at the junction of the superciliary arches on the midline, above the root of the nose. The **nasion,** or **root of the nose,** is located immediately below the superciliary arches, forming a sharp angle at the top of the bridge of the nose. The **nasal aperture** is an upside-down heart-shaped opening whose width and height varies according to race. Superiorly, the **nasal bones** form the bridge of the nose, whose surface is directed forward and upward. The front plane of the nasal bones widens inferiorly where it meets the nasal cartilages. Projecting forward from the bottom of the nasal aperture are the pointed **anterior nasal spines,** marking the base of the nose (located at the level of the base of the cranium).

The subcutaneous **zygomatic arch** is the widest part of the face. Its upper edge, at the level of the lower border of the orbit, is horizontal. Narrow posteriorly, it expands into the cheekbone anteriorly. Viewed from above, the zygomatic arch curves outward. Posteriorly, it curves back in toward the skull, ending just above the ear hole (at the top of the tragus of the ear in life). The anterior plane of the cheekbone is directed forward and downward and is parallel to the plane of the nasal aperture. The bottom point of the cheekbone lies at the same level as the bottom of the nasal aperture and the bottom of the cranium.

The *MANDIBLE,* or lower jaw, consists of a horizontal body, which contains the teeth, and a thin, flat, vertical ramus. The **ramus** is forked superiorly; the posterior fork terminates at the **condylar process,** and the anterior fork terminates at the pointed **coronoid process.** The posterior edge of the ramus is not covered by muscle, but is recessed in life. The condylar process articulates with the skull in the notch under the posterior end of the zygomatic arch, just anterior to the ear hole. This articulation is called the **temporomandibular joint** (TMJ). The outer end of the condylar process can be seen and felt moving forward and back as the jaw is opened and closed. When the jaw is opened, the condylar process moves forward, and a depression forms in front of the tragus of the ear in life, where the condylar process was previously located.

The **body of the mandible** is V-shaped, as seen from the bottom view. The apex, at the chin, is squared-off and blunt in the male; it is more pointed in the female. The prominent **mental tubercles,** located a short distance from the midline on the bottom of the front of the chin, are more developed in the male. The single anterior pointed projection of the chin is called the **mental protuberance.** A uniquely human characteristic, it is located slightly up from the bottom edge of the chin on the midline in front.

The middle third of the outer surface of the body of the mandible swells outwardly. The bottom edge of the body, when seen in side view, inclines upward and backward and meets the posterior edge of the ramus of the mandible at the **angle of the jaw.** The lower edge may develop a series of curvatures (side view). The angle of the jaw is usually rounded, but it may also be pointed; at times it is everted laterally. The width of the angles of the jaw is equal to the width of the outer borders of the orbit (front view).

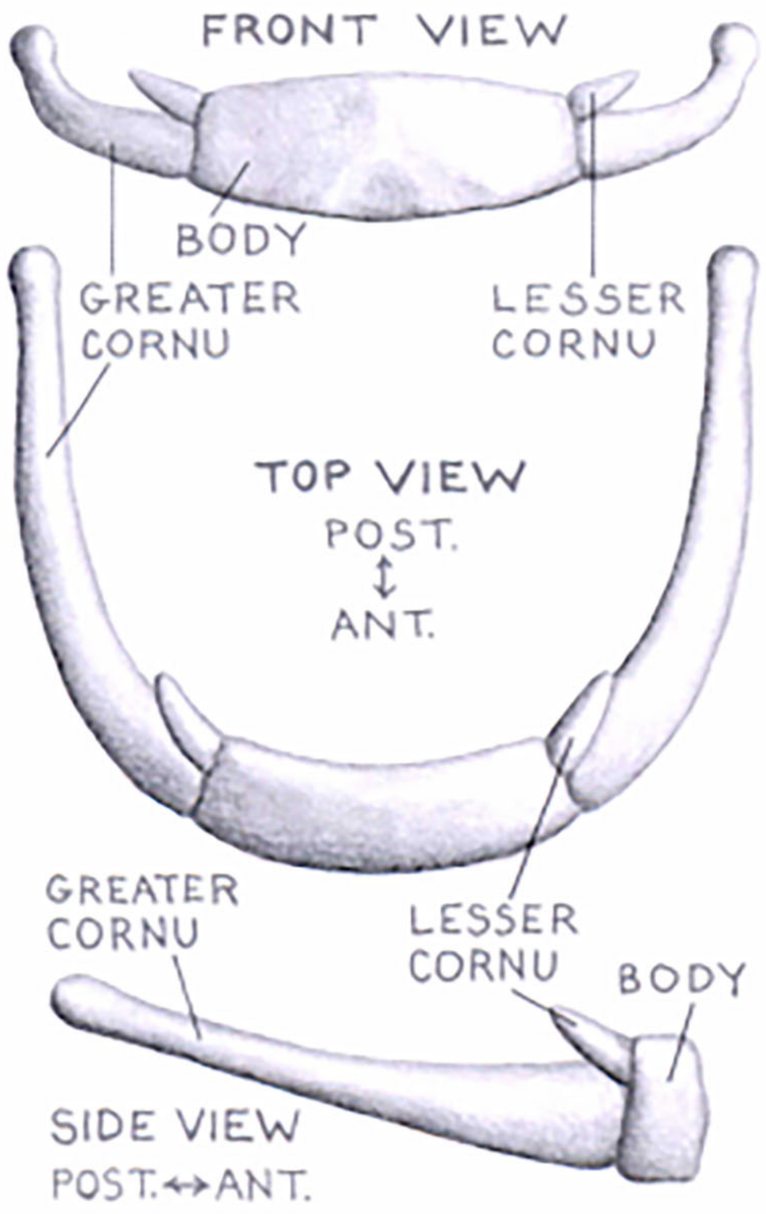
The **muzzle,** made up of the teeth and the bony socket rows of the maxilla and mandible, is roughly cylindrical. Its curvature is best seen when the lower jaw is removed from the skull and the rounded tooth rows are examined. The tooth rows are U-shaped, with the sides of the U diverging posteriorly, not parallel. The form of the muzzle is actually more spherical. Its double-curved form is made up of the previously mentioned cylinder (transverse curvature) along with the anterior projecting curve of its front profile (longitudinal curvature). The muzzle form is slightly wider than the centers of the orbits. The lips sit on this cylindrical muzzle and reflect its curvature; this is especially evident when the head is tipped back.

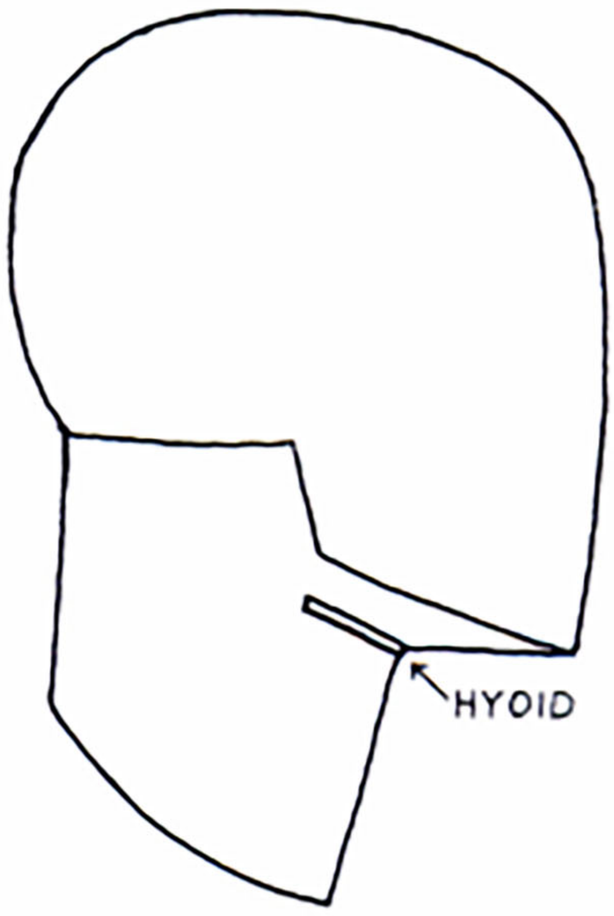
In the normal relaxed position, the lower jaw is held in a position where the teeth don't touch. When the jaw is closed, the chewing surfaces of the back teeth touch, while the upper front teeth overlap the lower front teeth.

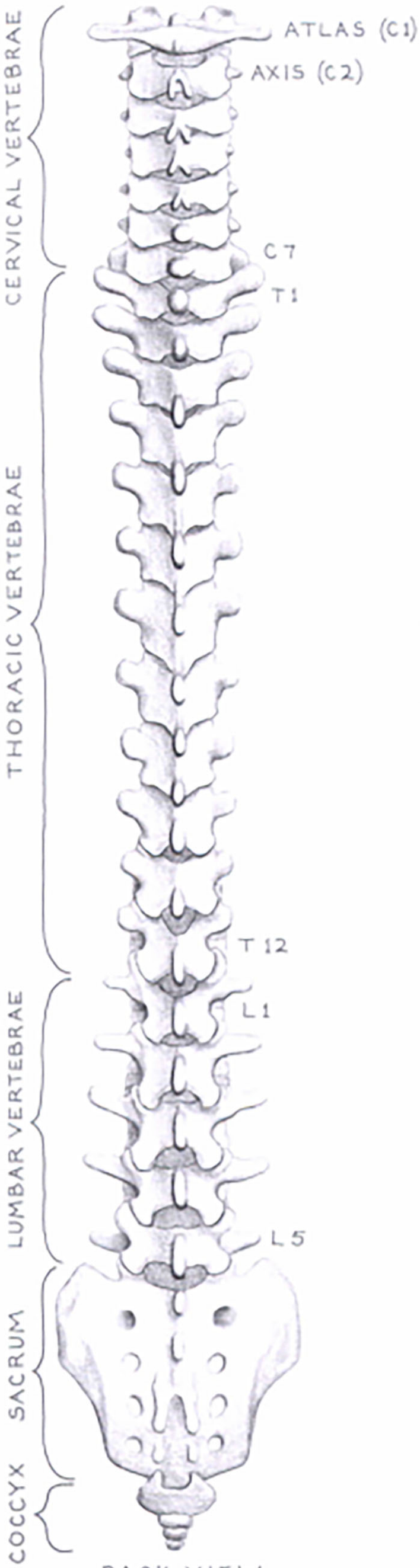
The halfway point from the top of the skull to the bottom of the jaw lies just below the center of the orbits, and the halfway point from front to back is at, or just behind, the temporomandibular joint. On average, the male skull is larger, more angular, and more robust than the more delicate skull of the female.

The *HYOID BONE* is a small, thin, U-shaped bone located at the top of the throat in the angle where the front of the neck meets the bottom plane of the lower jaw. It is thick in front and thin on its sides. Its U shape reflects the cylindrical quality of the form of the throat. The hyoid is basically a floating bone, suspended by ligaments from the base of the cranium and stabilized by numerous muscles attached to it. Not directly visible, it can be felt a finger's width above the laryngeal cartilage (Adam's apple). The hyoid moves up and down while swallowing and also when extending and flexing the head. The front of the hyoid is situated at a level lower than the chin, therefore the profile in side view of the bottom plane of the lower jaw is directed backward and slightly *downward*. When the head is extended, a depression forms at the posterior end of the hyoid. Although this depression is very subtle, it helps identify the location of the hyoid.

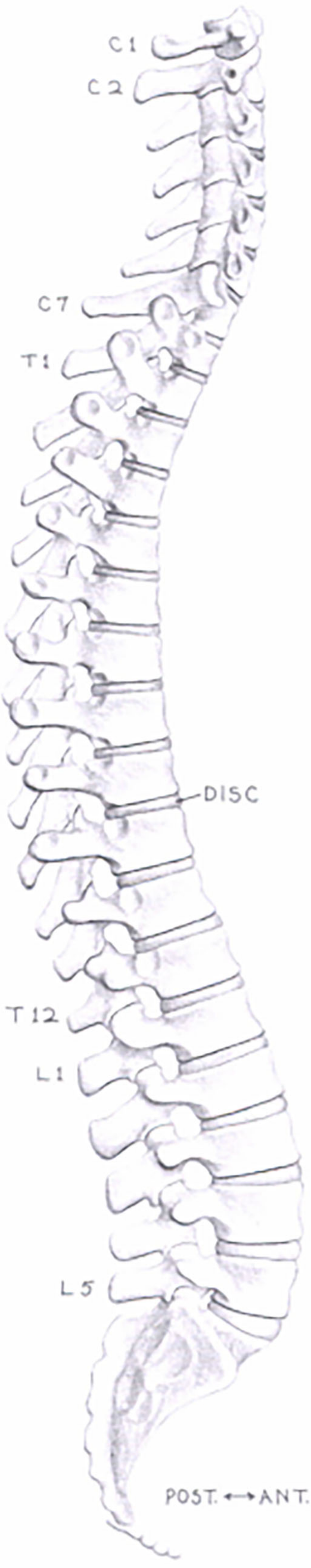
HYOID



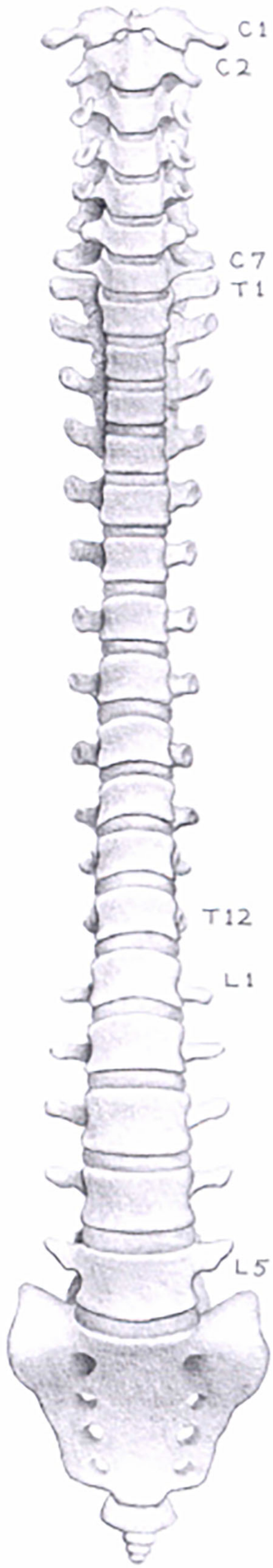




BACK VIEW



RIGHT SIDE VIEW



FRONT VIEW

The *VERTEBRAL COLUMN,* spinal column, spine, or backbone is made up of the **vertebrae** and intervening fibrocartilaginous **discs.** It functions both as a rigid column of support for the head and thorax, as well as a flexible column capable of motion. The vertebral column is thicker inferiorly as the lower vertebrae increasingly support more weight. There are twenty-four movable or true vertebrae and nine fixed or false vertebrae, arranged as follows: seven cervical (neck) vertebrae, twelve thoracic (dorsal or chest) vertebrae, five lumbar (lower back) vertebrae, five fused sacral vertebrae (forming the sacrum), and four partially fused coccygeal vertebrae (forming the coccyx).

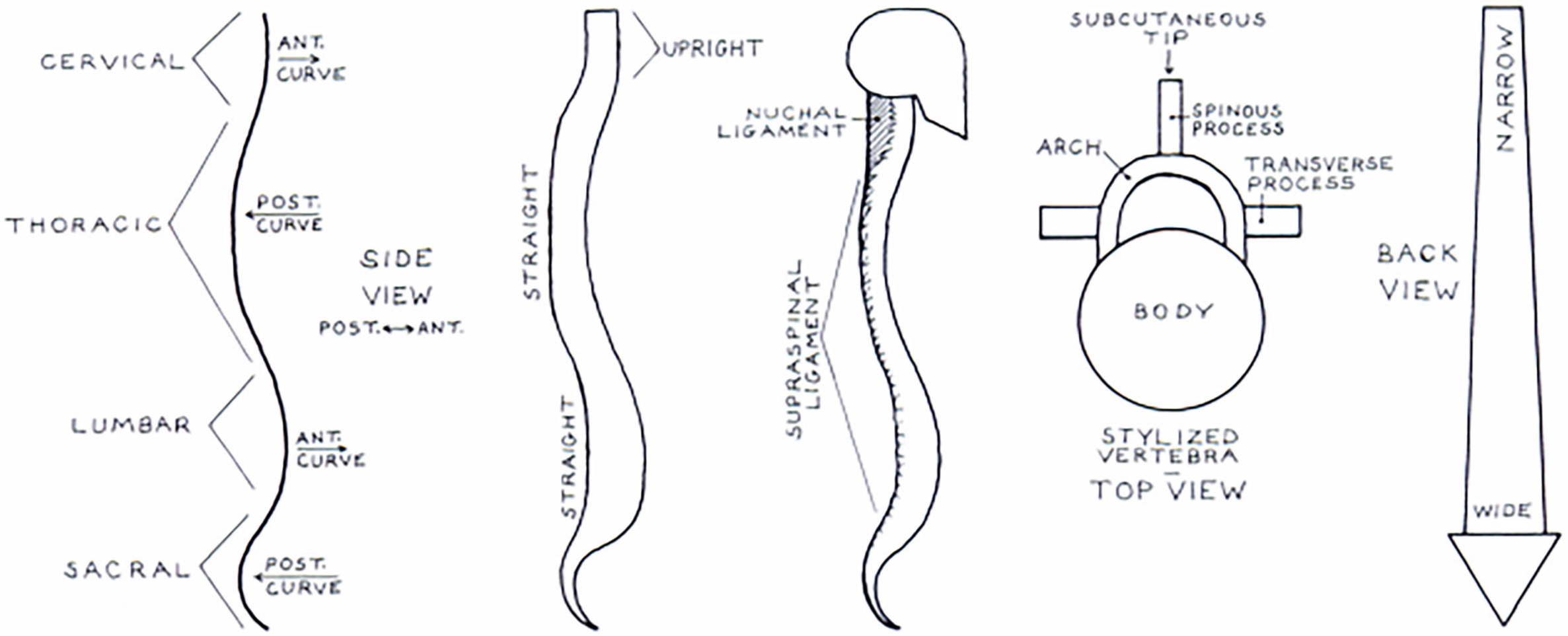
Because of the upright posture of humans, the vertebral column has **four curves,** enabling the body masses to be balanced one over the other. This design uses the least amount of muscle energy in maintaining a balanced alignment. The two forward curves are formed by the cervical and lumbar vertebrae; the two backward curves are created by the thoracic vertebrae and the sacrum and coccyx together (the pelvic curve). In side view, the deep anterior profile has a more pronounced curvature than does the posterior profile along the projecting spinous processes. The spinal curves are increased or straightened as the vertebral column is flexed or extended.

The thoracic vertebrae form part of the rib cage, and the sacrum, locked between the two pelvic bones to form the back of the pelvic girdle, supports the movable portion of the vertebral column above. The cervical vertebrae support the head; the lumbar vertebrae support the thorax (as well as the head and neck). The cranium sits on the top of the vertebral column; the top end of the spine lies behind the mouth.

The subcutaneous tips of the spinous processes are located on the midline of the back. They are not seen in the side view of the standing figure because of the posterior projection of the back muscles and the shoulder blade. They are found at the bottom of a groove, the **spinal furrow,** formed by the bulging back muscles on either side, and may or may not be seen on the surface in the erect posture. The spinal furrow extends from the back of the base of the neck to halfway down the sacrum. It stops at the flatness on the posterior surface of the sacral triangle and continues inferiorly as the gluteal cleft between the buttocks. It is deepest in the lumbar region.

As the spine is flexed forward, the spinous processes (including those of the sacrum) become more conspicuous, and may eventually form a raised ridge made up of interconnected projecting points at full flexion. The spinous processes may display varying degrees of prominence, based on their obliquity, length, and thickness. When the thorax is bent laterally, the thoracic and lumbar vertebrae assume a single long curve when seen from the rear. However, the upper thoracic region tends to remain straight, with most of the curvature in the lower back.

Except for the first cervical vertebra, sacrum, and coccyx, each *VERTEBRA* consists of a drum-shaped **body** with an attached horizontal bony **arch.** The bodies of the thoracic vertebrae are slightly wedge-shaped, helping to form the thoracic curve. A **transverse process** projects off each side of the arch, and a **spinous process**



attaches to the back of the arch. The tips of the spinous process of the seventh cervical and sometimes the upper two thoracic vertebrae are pointed; all the others below have squared-off posterior borders that appear subcutaneously as short raised vertical ridges. **Articular facets** above and below each side of the arch, which articulate with the adjoining vertebrae, determine the direction and degree of motion (flexion, extension, lateral bending, rotation) between the vertebrae. Extent of motion is also controlled by the ligaments that connect the vertebrae.

The cordlike ligament connecting the tips of the spinous processes in back, from the seventh cervical vertebra to the sacrum, is called the **supraspinal ligament.** From the seventh cervical vertebra to the skull, this ligament continues upward as the sheetlike **nuchal ligament,** or posterior cervical ligament. The elastic nuchal ligament—located in the midline of the neck—forms a vertical septum between the neck muscles on both sides. Its free posterior border attaches to the external occipital protuberance at the base of the skull and to the spinous process of the seventh cervical vertebra. Deep in the neck, its anterior edge attaches to the spinous processes of the other cervical vertebrae. When the head is upright, the posterior free edge of the nuchal ligament is located at the bottom of a groove formed by the columnar bulging neck muscles on each side of the midline. When the head and neck are flexed forward, the nuchal ligament forms a palpable raised vertical ridge on the midline of the neck.

The vertebral bodies of all of the movable vertebrae are separated from each other by elastic fibrocartilaginous **intervertebral discs** (except between the first and second cervical vertebrae). The intervertebral discs allow only a small degree of motion between adjoining vertebrae, but cumulatively over the entire vertebral column, the range of motion can become quite extensive. The wedge shape of the cervical and lumbar discs helps create the spinal curves.

The seven *CERVICAL VERTEBRAE,* except for the spinous process of the seventh (and sometimes the sixth), are completely buried deep in the neck. The spinous process of the **seventh cervical vertebra** (**vertebra prominens**) is an important conspicuous bony landmark. At times, the spinous process of the first thoracic vertebra may be more prominent than that of the seventh cervical. The first cervical vertebra, which supports the skull, is called the **atlas.** Its body is replaced by a bony arch, and it has no spinous process. The second cervical vertebra, the **axis,** has a vertical bony projection, the **dens,** or **odontoid process,** that rises off the upper surface of its body and projects through the anterior arch of the atlas; thus the atlas rotates around the vertical dens of the axis.

The twelve *THORACIC VERTEBRAE* have a backward curve. The curvature of the back profile is straighter than the anterior profile because the spinous processes of the fourth through ninth vertebrae are directed obliquely downward, straightening the middle part of the curve. These middle thoracic spinous processes, and sometimes the lower thoracic spinous processes, are not prominent on the surface; at times they are not seen at all, even when the spine is fully flexed forward. Each thoracic vertebra articulates with a rib on each side.

The five *LUMBAR VERTEBRAE* have an overall forward curvature. The back profile may be curved forward (as in the front profile), straight, or even curved backward, depending on the extent of the projection of the strong, rectangular, spinous processes. The greater the forward tip of the pelvis, the more forwardly curved is the lumbar curvature ("arched back"). The lumbar spinous processes are longer vertically than the thoracic spinous processes.

The *SACRUM* is made up of five vertebrae fused into a rigid triangular bone, and is locked in-between the two iliac bones of the pelvis. Because most of the posterior surface of the sacrum is covered by muscle, the **sacral triangle,** formed by connecting the posterior pelvic points with the top of the gluteal cleft (seen on the surface in life), is smaller than the actual size of the sacrum itself.

The subcutaneous spinous processes of the sacrum form a median crest on the back surface of the upper two-thirds of the sacrum. The crest ends inferiorly at an upside-down V-shaped notch, the **sacral hiatus.** Sometimes, the crest is at the bottom of a furrow when the figure is erect, with the muscle columns bulging slightly on either side. This area of the sacral triangle can also be flat with a simple posterior curve and no furrow. The width of the sacrum is approximately equal to one-third the width of the widest part of the pelvis.

The *COCCYX,* usually made up of four vertebrae (it varies from three to five), is the vestigial mammalian tail. It is not distinctly seen on the surface, but continues the backward curve of the sacrum before disappearing in the vertical gluteal cleft. It has no spinous processes. Its inferior tip lies at the level of the top of the pubic symphysis, which is approximately the halfway point of the figure. The first coccygeal vertebra, articulating with the sacrum, is considerably larger than, and is never fused to, the other coccygeal vertebrae. The remaining small block-like coccygeal vertebrae diminish in size inferiorly and are often fused to one another.

The *RIB CAGE* is made up of twelve pairs of ribs, their costal cartilages, the sternum, and the thoracic vertebrae. It forms a semirigid enclosure, protecting the internal organs, and allows negative pressure to develop within for breathing. The rib cage is a large egg-shaped form—tapered superiorly, widened inferiorly, and flattened from front to back—with a relatively small opening on top. Its vertical axis inclines slightly backward in the standing position. Inferiorly, the rib cage has a very large opening, which is wider side to side than front to back.

The inferior opening extends upward in front to create a large upside-down *V*-shaped notch where the costal cartilages of the seventh ribs attach to the bottom of the sternum. This notch is called the **infrasternal angle, costal angle, costal arch,** or **skeletal arch.** The infrasternal angle is approximately 90° in the male and smaller, around 60°, in the female. The angle increases during inhalation.

The rib cage can be visualized as having a bell-shaped or barrel-shaped form. The lower half of the rib cage, covered only by a thin layer of muscle, directly determines the trunk's shape in that area in life. The upper half of the rib cage, although covered for the most part by the shoulder girdle and the pectoral muscles, reveals its basic shape in front, in back, and in the armpits as the shoulder apparatus moves upward, forward, or backward.

In the female the rib cage is smaller, shorter, and located farther away from the iliac crest than in the male. The width of the male rib cage ranges from being slightly wider than to slightly narrower than the width of the iliac crests of the pelvis; in the female, the rib cage is always narrower. The overall form of the rib cage increases in width and depth during inhalation. This happens because the ribs are raised during inhalation while pivoting at their articulations with the vertebrae.

The *RIBS* themselves are narrow, flat, bony arches that curve around from back to front. They all attach to the vertebral column. Anteriorly, each rib attaches to its own costal cartilage. The cartilages of the first seven ribs connect directly to the sternum, and these ribs are called **true ribs.** The cartilages of the eighth and ninth ribs attach to the costal cartilage immediately above, while that of the tenth rib only occasionally reaches the cartilage of the one above; these ribs are termed **false ribs.** (Sometimes, the cartilage of the eighth rib reaches the bottom of the sternum.) The short cartilages of the eleventh and twelfth ribs are not connected to any rib cartilages, and these ribs are considered both false and **floating ribs.**

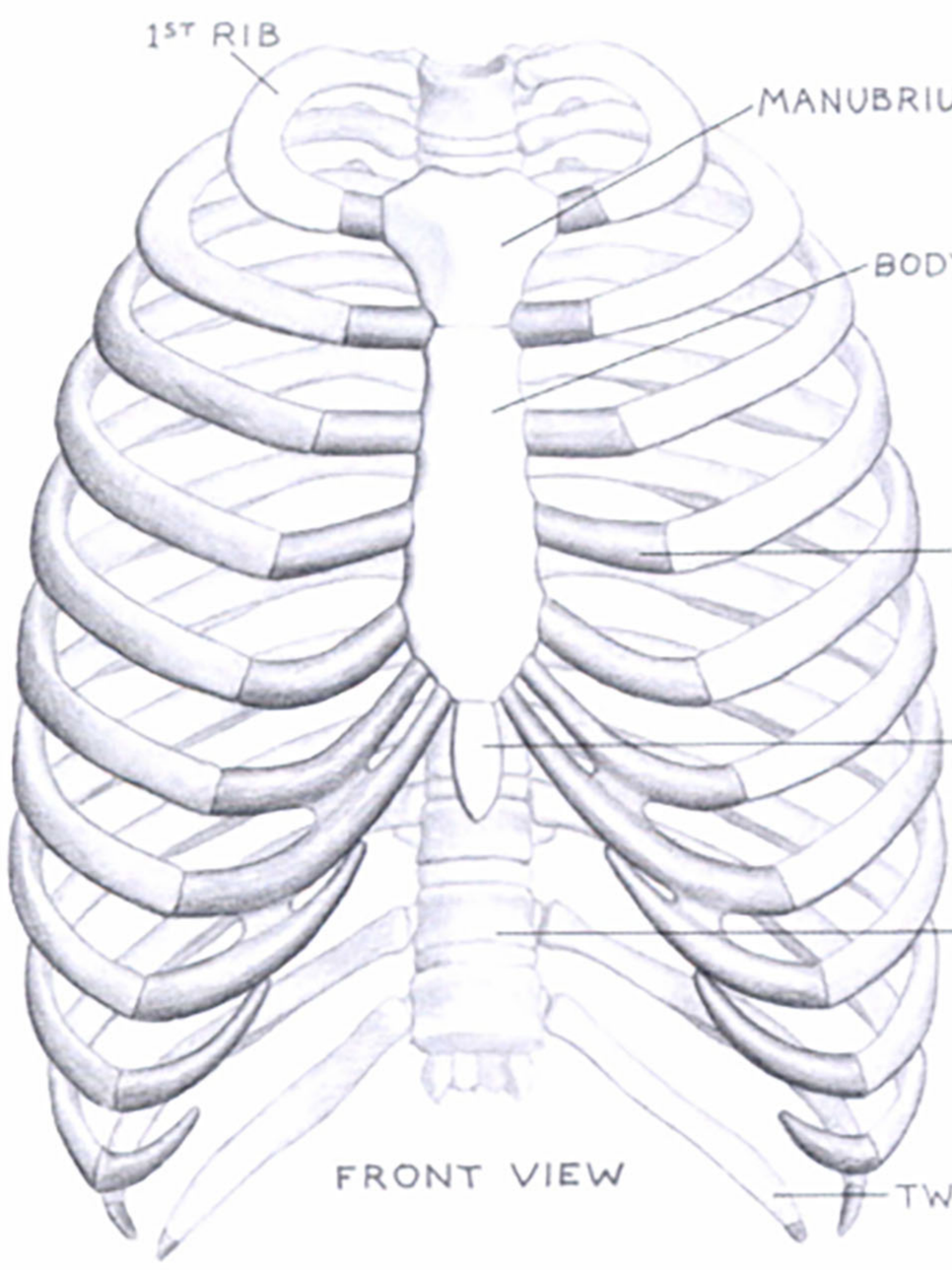
The planes of the outer surfaces of the individual ribs conform to the rounded surface of the overall form of the rib cage. The abrupt change of the curvature of each rib—on the back of the thorax, a short distance lateral to its articulation with the vertebrae—is called the **angle of the rib.** The line of the angles of the ribs is seen in life as the laterally convex outer border of the erector spinae muscle, because that muscle inserts onto the back of the ribs up to, but not past, the angles of the ribs. The side planes of the rib cage converge slightly anteriorly (see cross section).

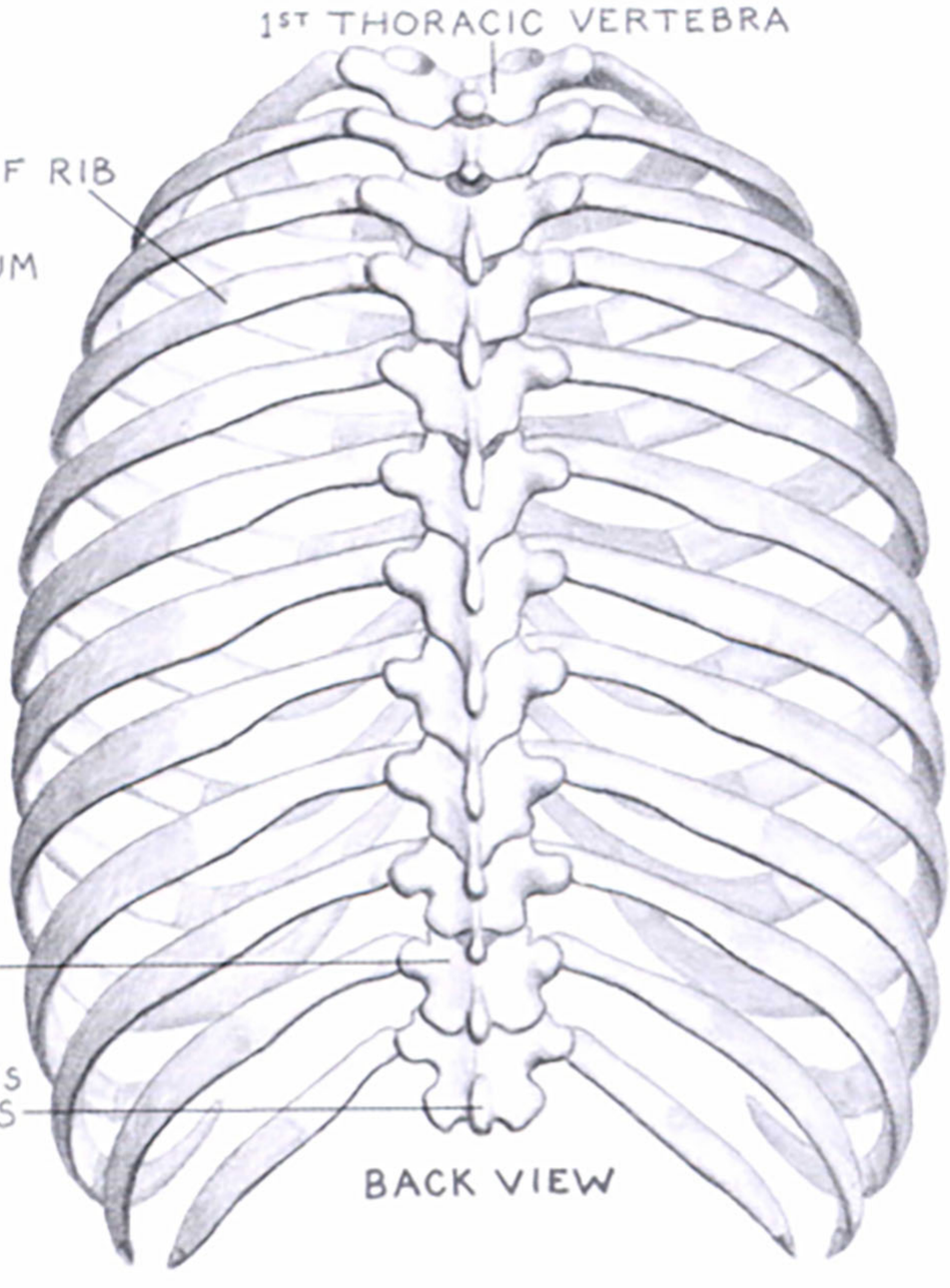
The individual ribs, seen from the side view, angle downward and forward (slightly less than 45° with the horizontal). They may have a slight S curve. The ribs become more horizontal during inhalation as their front ends rise, pivoting at their articulations with the vertebrae in back. Because areas of the lower half of the rib cage are covered only by a thin muscle layer, the individual ribs frequently become visible. They are especially noticeable on the front and sides when inhaling and on the back when the trunk is flexed forward and the shoulders are thrust forward.

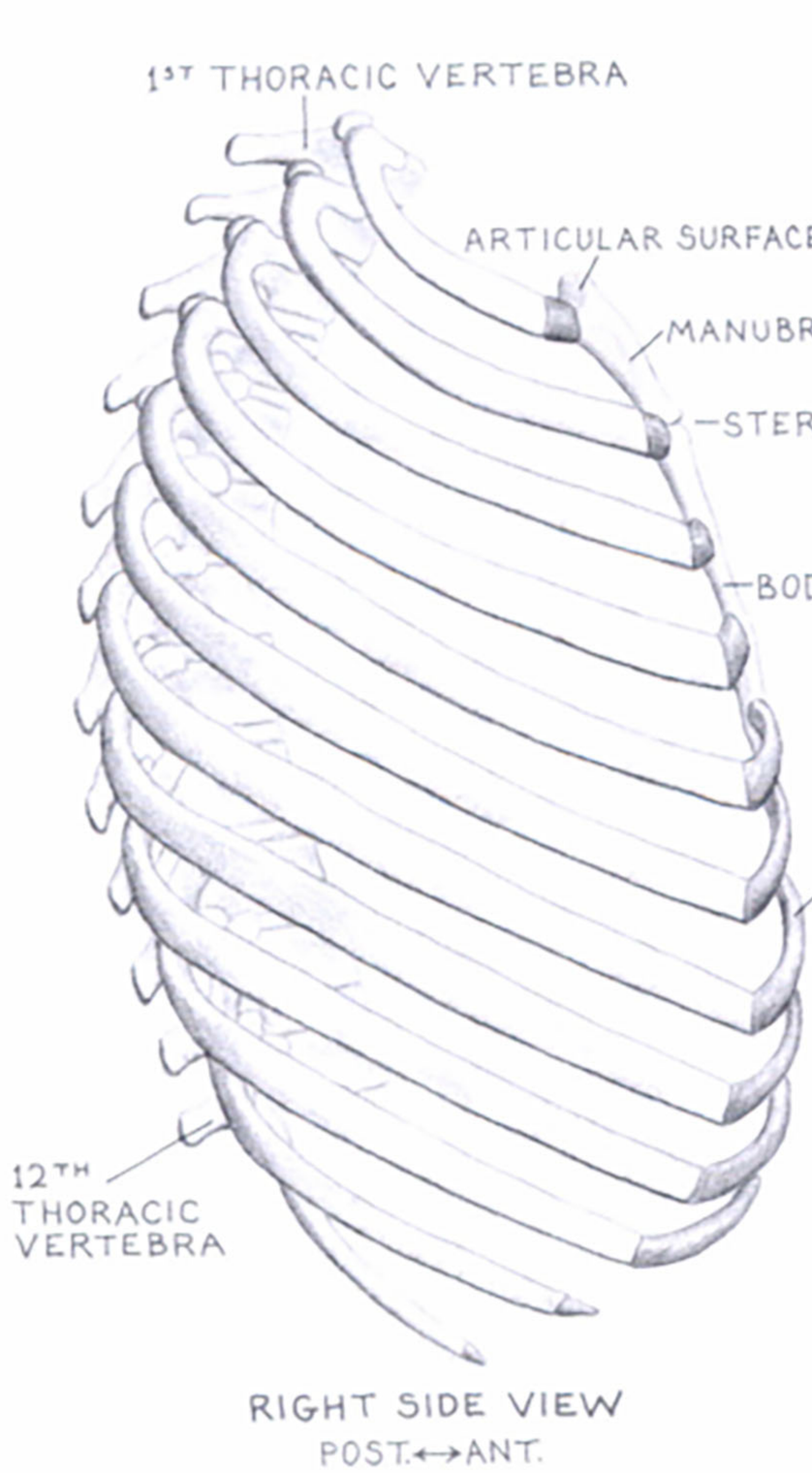
The posterior surface of the rib cage projects backward almost as far as the spinous processes of the vertebrae (see side view). Superiorly, there is increased posterior projection of the spinous processes of the upper thoracic vertebrae. The tip of the twelfth rib is the lowest point of the rib cage; in the male it can be as close as one inch from the iliac crest, much closer than is usually indicated in illustrations and in articulated skeletons. The distance is greater in the female than in the male.

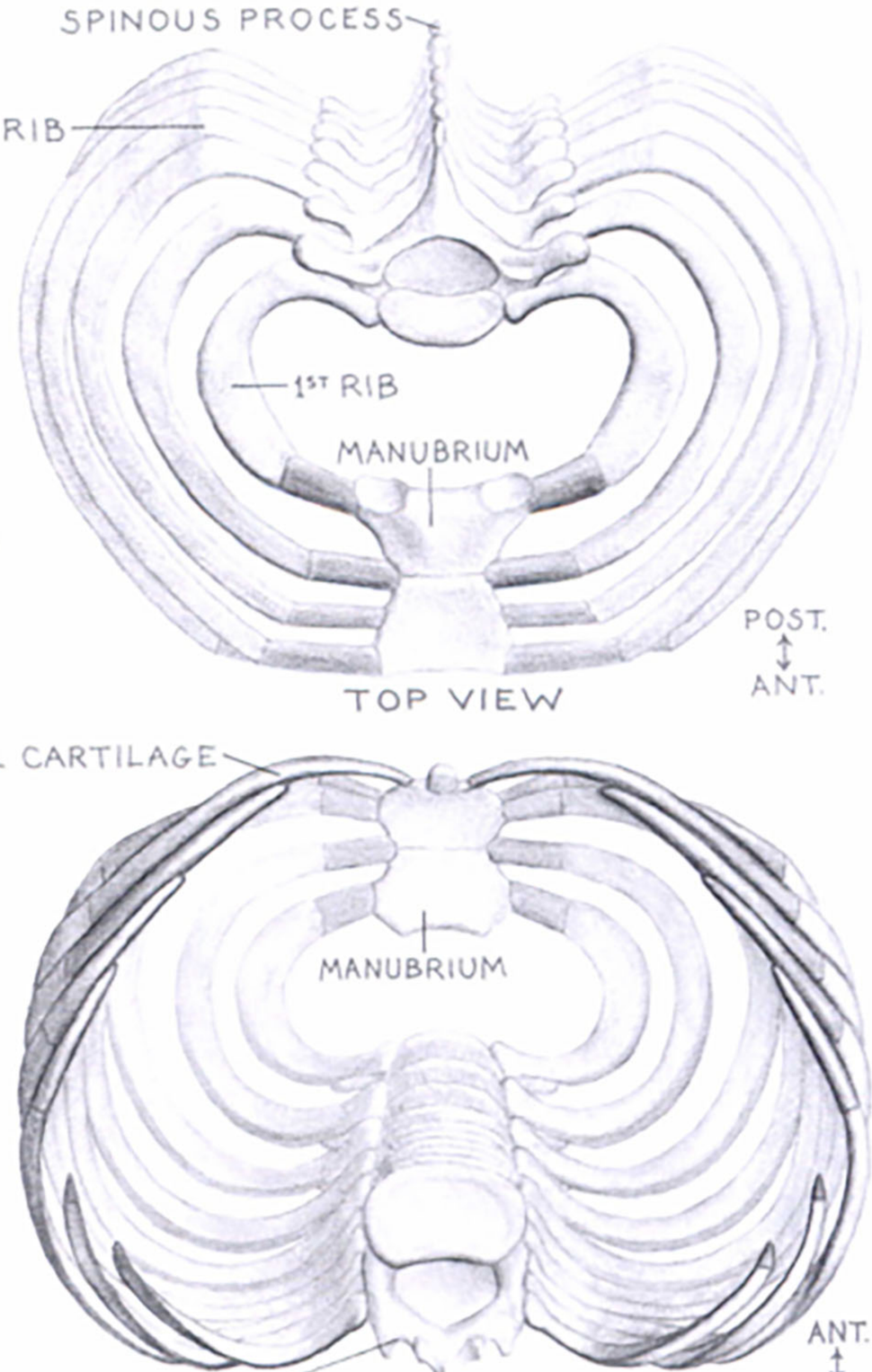
The *COSTAL CARTILAGES* are the cartilaginous extensions at the anterior ends of all the ribs. From the ends of the ribs, the cartilages of ribs five through eleven *curve* upward and medially; cartilages of ribs three and four generally are straight and directed upward and medially; the cartilage of rib two is usually horizontal; the cartilage of rib one is directed downward and medially. Except for the first two ribs, the cartilages taper medially, especially those of ribs eight through twelve, which are pointed. Along the middle of the lengths of the lower cartilages (usually the sixth through the eighth), adjacent cartilages come in contact with each other. The cartilages often swell at these points of contact.

The costal cartilages of the seventh ribs attach to the bottom of the body of the sternum and to the adjacent top of the xiphoid process. These costal cartilages of both sides meet at a *sharp angle* where they articulate with the sternum, creating the top of the costal or **skeletal arch.** Ligaments attaching the tips of these cartilages to the front surface of the xiphoid process may slightly soften and round off the sharp angle. The skeletal arch proceeds down along the


1ST RIB
MANUBRIUM
BODY OF STERNUM
COSTAL CARTILAGE
XIPHOID PROCESS
VERTEBRAL COLUMN
TWELFTH RIB
FRONT VIEW


1ST THORACIC VERTEBRA
ANGLE OF RIB
SPINOUS PROCESS
BACK VIEW


1ST THORACIC VERTEBRA
ARTICULAR SURFACE FOR CLAVICLE
MANUBRIUM
STERNAL ANGLE
BODY OF STERNUM
7TH COSTAL CARTILAGE
12TH THORACIC VERTEBRA
RIGHT SIDE VIEW
POST.↔ANT.


SPINOUS PROCESS
ANGLE OF RIB
1ST RIB
MANUBRIUM
TOP VIEW
POST.
ANT.
MANUBRIUM
12TH THORACIC VERTEBRA
BOTTOM VIEW
ANT.
POST.

lower edge of the cartilages of ribs seven through ten on each side of the body. Looking at the skeletal arch from the front view in life, its sloping side may form either a straight line, a single downward convex curve, or a series of four convex curves of various lengths: the seventh and eighth cartilages create long curves, and the ninth and tenth cartilages, short curves. At times, such as when inhaling, the costal cartilages together may develop a single upward convex curvature, seen in the front view.

In side view, the combined anterior projection of costal cartilages seven through ten may show up as a single rounded forward projection or may form a straight profile, inclined down and back.

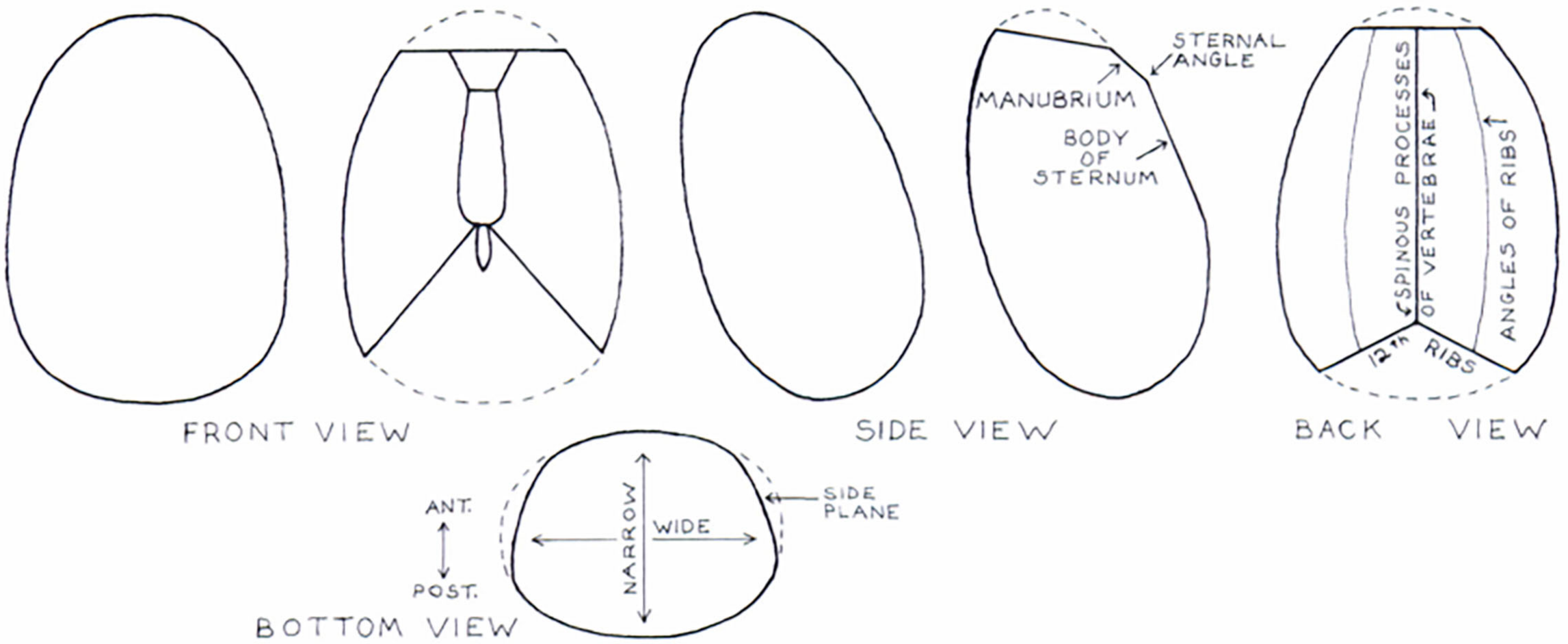
The costal cartilages of the seventh and eighth ribs may curve anterior to the plane of the sternum, which places the lower end of the sternum on a slightly recessed plane (see bottom view).

The connection of a rib to its costal cartilage is called a **costochondral articulation.** The costochondral articulation of the fifth rib lies at the level of the bottom of the sternum. The connection of a costal cartilage to the sternum is called a **sternocostal articulation.** Except for the first rib, these articulations are true synovial joints. The intervals between the sternocostal articulations of succeeding ribs (along the lateral edge of the sternum) diminish inferiorly, to the point where there is no space left between the sternocostal articulations of the sixth and seventh ribs. In thin individuals, the costal cartilages and the sternocostal and costochondral articulations may be seen on the surface in life under a thin pectoralis major, especially under the upper half of the muscle. (The lower half of the pectoralis is thicker.) The costochondral articulations inferior to the lower border of the pectoralis major may also be seen on the surface, especially during inhalation.

The **semilunar line** located between the rectus abdominis and the external oblique, crosses the tip of the tenth costal cartilage. The bottom of the curvature of the tenth cartilage, just lateral to the semilunar line, is often prominent and indicates the bottom of both skeletal and abdominal arches.

The *STERNUM,* or breastbone, is made up of the manubrium, the body of the sternum, and the xiphoid process. In the female the sternum is shorter and usually more arched forward than in the male.

The upper shieldlike portion of the sternum, the **manubrium,** is short and wide. It meets the body of the sternum at an angle, the **sternal angle,** usually visible on the surface. The plane of the manubrium is directed more upward than the plane of the body of the sternum. The prominence of the sternal angle is also due to the swelling of both the lower edge of the manubrium and the upper edge of the body of the sternum into thickened lips or ridges where they are in contact with each other. The costal cartilage of the second rib attaches to the sternum at the sternal angle, which makes it a good point to begin counting the ribs in life. The medial ends of the clavicles articulate with the upper outer corners of the manubrium, and, along with the upper edge of the manubrium, form the **suprasternal** (**jugular**) **notch,** also called the



pit of the neck. Because the level of the pit of the neck is lower than the spinous process of the seventh cervical vertebra in back, the neck descends lower in front.

The **body, blade,** or **gladiolus** of the sternum is elongated and slightly teardrop-shaped. It has a gentle anterior curve. Three evenly spaced faint transverse ridges on the front surface of the blade, remnants of its earlier segmented structure, may be seen on the surface in life. The uppermost ridge (the first ridge below the sternal angle), where the third costal cartilage articulates with the sternum, may be quite prominent, occasionally even more so than the sternal angle. The bone of the body of the sternum swells slightly at the sternocostal articulations, which may be seen on the chest in life.

The pectoralis major muscles of both sides usually don't meet at the midline, but rather leave a narrow subcutaneous strip of the sternum at the bottom of a groove located between these bulging chest muscles. This flattened, bony furrow between the muscles gets deeper inferiorly as the pectoralis thickens. The furrow also gradually widens as it descends. The lower end of this subcutaneous furrow expands into a flat triangular area, exposing the front surface of the lower end of the body of the sternum. The lower edge of the body of the sternum is located below the level of the nipples and above the level of the lower border of the pectoralis major. A depression termed the **infrasternal notch** or **epigastric depression** (at the apex of the skeletal arch) forms immediately below the inferior edge of the body of the sternum. The upper border of this depression is formed by the tips of the costal cartilages of the seventh ribs attaching to the inferior end of the body of the sternum.

The **xiphoid process,** or **ensiform cartilage,** is a thin, flattened cartilage attached to the bottom of the body of the sternum. It projects downward and slightly forward. Superiorly, it lies on a slightly deeper plane than the front surface of the body of the sternum, which helps create the epigastric depression. Variable in size (it averages the size of the distal phalanx of the thumb) and shape (oval, triangular, wide, narrow, pointed, forked, or perforated), its inferior tip may project forward and appear as a small pointed eminence in life. Later in life, the upper portion of the xiphoid process begins to ossify (become bony).

The *CLAVICLE,* or collarbone, articulates medially with the manubrium of the sternum, and laterally with the *inner* border of the acromion of the scapula. The articulation at the sternum is the only bony connection between the entire shoulder girdle and the rest of the skeleton. The clavicle appears straight when viewed from the front and has an S curve when seen from above or below. The clavicle begins on the front of the thorax where the neck meets the chest and ends at the middle of the top of the shoulder (on the midfrontal plane of the body). Its medial two-thirds projects forward as a long anterior curve. The lateral third has a short, tight, backward curve. The two clavicles together form an "archer's bow" when seen from the top view.

The medial two-thirds of the **body** of the clavicle is cylindrical; the lateral third is wider and flattened from above to below. The acromial or **lateral end** is the highest point of the shoulder, situated at a level slightly higher than the acromion process of the scapula. The tip of the lateral end may become so prominent that it appears as a distinct round bump on the surface in life. The sternal or **medial end** expands into a prominent, somewhat conical form. The anterior surface of the medial expansion sits slightly forward of the anterior surface of the sternum.

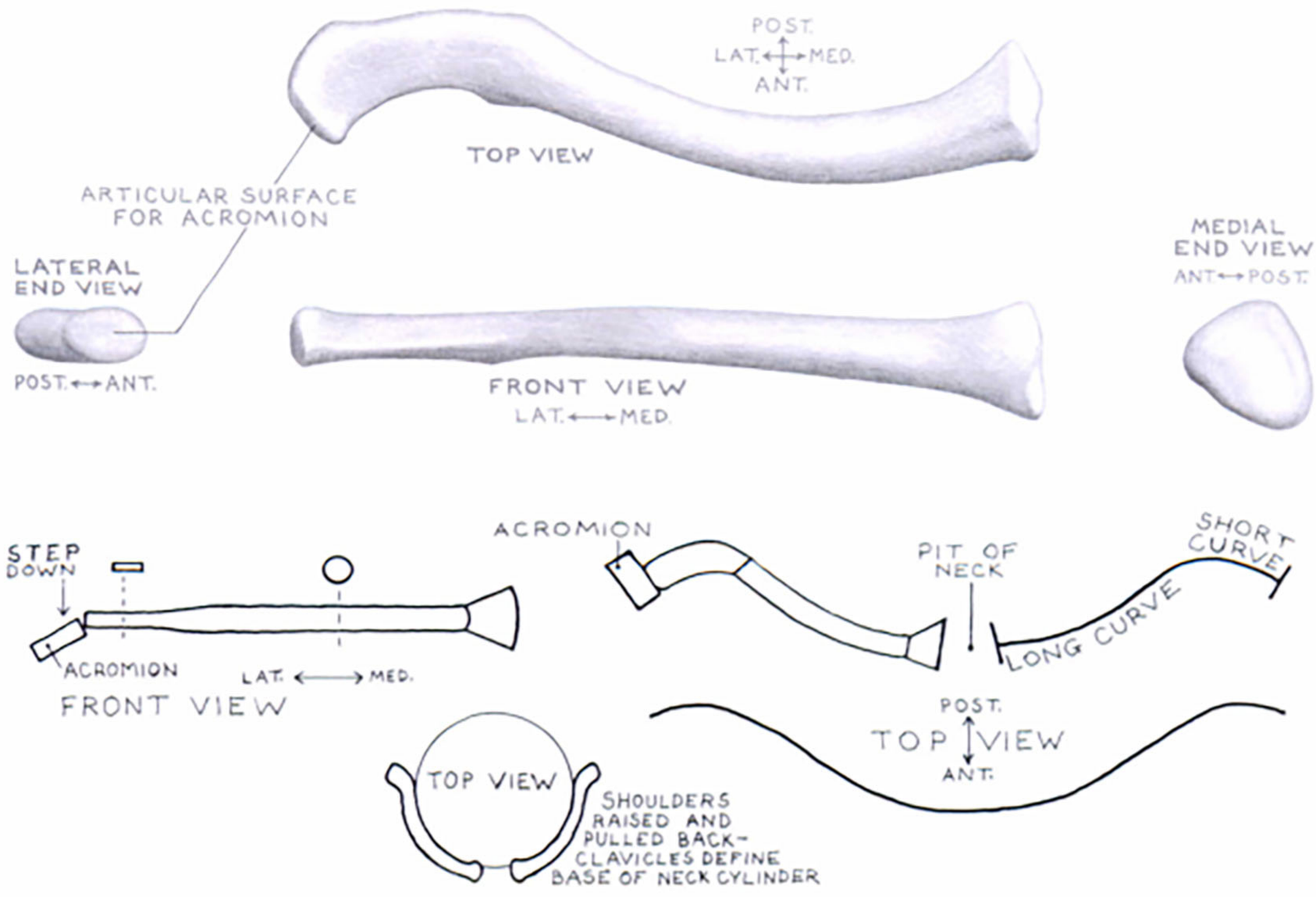
The **pit of the neck** or **suprasternal notch** is the depression at the top of the sternum where the neck meets the chest. The notch is formed by the separation between the medial ends of the clavicle (about one inch apart).

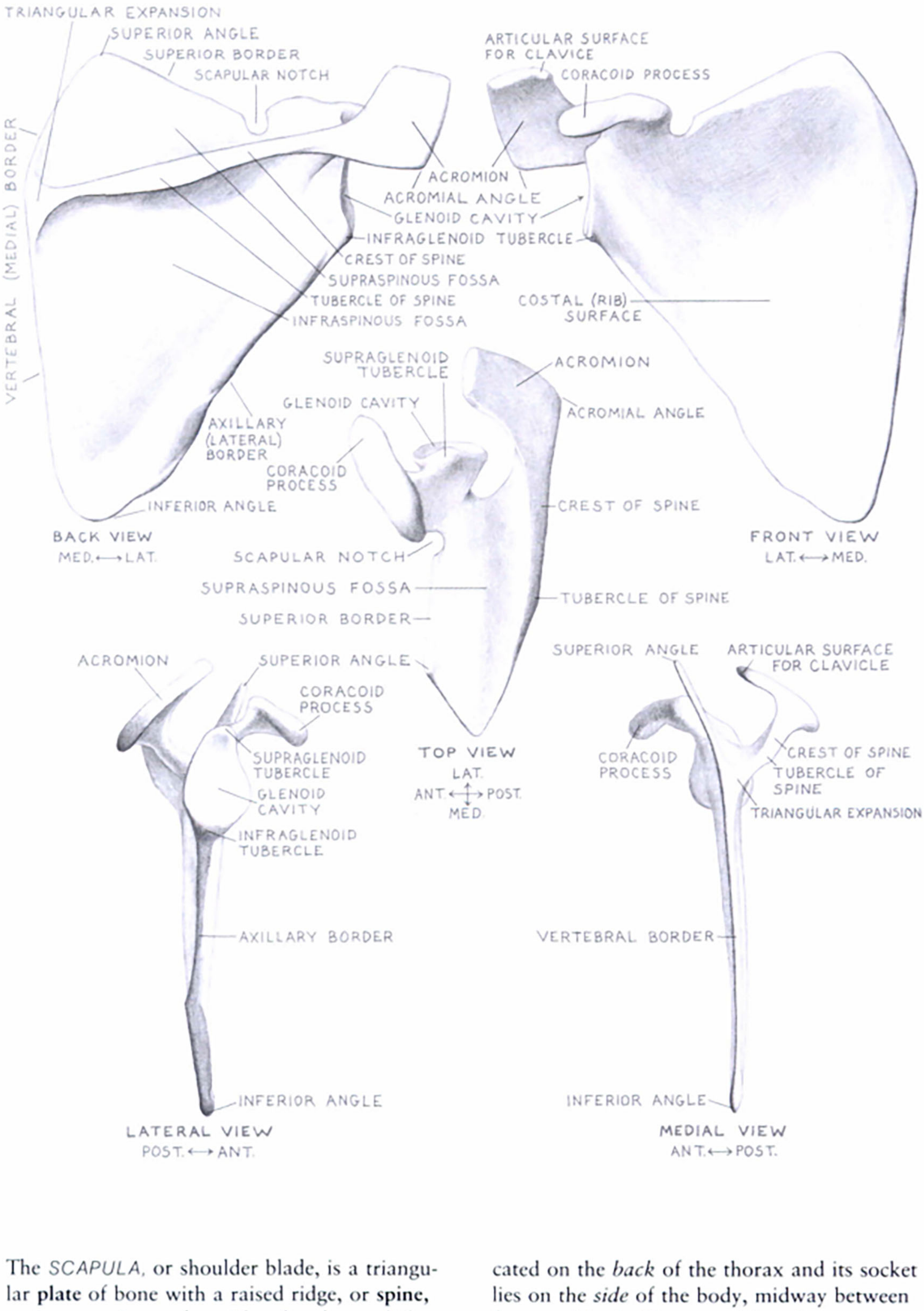
The front and top surfaces of the clavicle are usually visible in life. Laterally the insertion of the trapezius onto the clavicle and the origin of the anterior deltoid from the clavicle approach each other as these muscles become developed and enlarged. The muscle fibers often obscure the form of the lateral portion of the clavicle.

An anteriorly directed bony projection of varying size is occasionally found one-fourth of the way in from the lateral end of the clavicle, on its anterior aspect (where the long anterior curve meets the short posterior curve). The anterior portion of the deltoid originates, in part, from this projection.

With the arms at rest, the clavicles either sit horizontally or incline upward toward their lateral ends. On occasion, they may incline downward, lowering the shoulder and making the neck appear longer. When the shoulder is raised, the hollow behind its middle third, the **supraclavicular fossa,** deepens. When both shoulders are raised and pulled back, the anterior curves of the two clavicles form a bony ring around the cylindrical base of the neck (which explains why the clavicles have their S-shaped curves). When the arm is raised straight up, the clavicle becomes less prominent, and its lateral end becomes concealed in a groove. In this position, appreciating its S-shaped curvature provides an important key to understanding the way the neck, shoulder, and upper chest muscles meet at the base of the neck.

RIGHT CLAVICLE

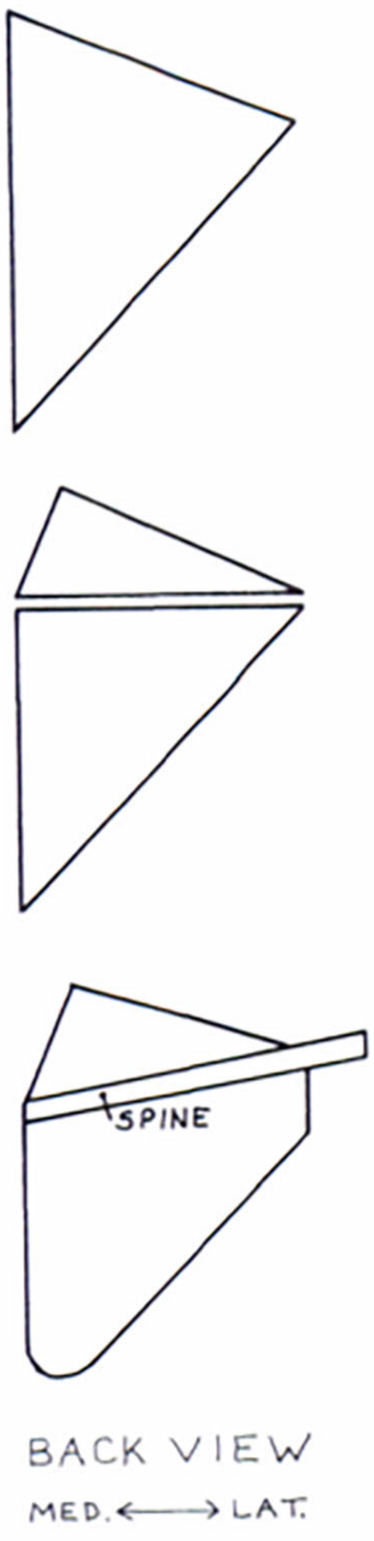




The *SCAPULA,* or shoulder blade, is a triangular **plate** of bone with a raised ridge, or **spine,** on its posterior surface. The plate has a slight convex curvature which glides upon the rounded surface of the rib cage (it is not as rounded as the rib cage). The scapula is separated from the rib cage by a substantial muscular layer, consisting of the subscapularis and serratus anterior.

The plane of the scapula is directed backward and outward, so that its vertebral border is located on the *back* of the thorax and its socket lies on the *side* of the body, midway between front and back. The scapula's only bony connection to the axial skeleton is the articulation of its acromion with the clavicle, which in turn articulates with the sternum. Laterally, the scapula articulates with the head of the humerus to form the shoulder joint. The clavicle, the scapula, and the manubrium of the sternum make up the **shoulder girdle.**

The inferior two-thirds of the **vertebral** (**me-**



dial) border is typically straight. It often has a convex curve medially and is occasionally concave. The portion of the vertebral border from the base of the spine downward often appears as a raised blunt ridge in life. It may project quite a distance away from the rib cage, which in extreme cases is referred to as "winging of the scapula." The portion of the vertebral border above the base of the spine may occasionally be seen under a thin or stretched muscle layer. The **lateral (axillary) border** and the **superior border** are deep.

The **superior angle** is sometimes found on the surface beneath the trapezius. The **inferior angle,** although surrounded by and partially covered by muscle, shows up as an important landmark. The shoulder socket is called the **glenoid cavity.** It is a shallow socket that receives the much larger articular surface of the head of the humerus. The **supraglenoid tubercle** on the upper edge of the socket, and the inferiorly prolonged **infraglenoid tubercle** on its lower edge, provide attachment areas for the long head of the biceps and the long head of the triceps, respectively.

The elongated **coracoid process** projects forward, laterally, and slightly downward. Its blunt tip ends in front of the shoulder joint. In life, the tip is located on the front of the shoulder, partially under the medial edge of the anterior portion of the deltoid and partially subcutaneous in the infraclavicular fossa. It may occasionally be seen and is easily palpated.

The **spine** of the scapula is a raised, elongated, triangular platelike ridge of bone projecting off the posterior surface of the plate of the scapula. It progressively projects further away from the plate as it passes laterally. The medial end of the spine is flush with the vertebral border. Where it widens into a smooth **triangular expansion.** This triangle appears in life as a flat triangular plane, either depressed owing to the surrounding bulging muscles or projecting slightly as a distinct triangular relief. It lies under the scapular aponeurosis of the trapezius, which glides over it. It is *not* covered by muscular fibers of the trapezius (or of any other muscle).

The subcutaneous posterior surface of the spine, or **crest of the spine,** forms a narrow plane that faces posteriorly. This plane has upper and lower lips or edges. Lateral to the triangular expansion at its base, the plane of the crest narrows, and then expands slightly into the **tubercle.** It constricts again lateral to the tubercle. At the shoulder joint, the crest turns sharply forward and expands into the large, flat, rectangular **acromion,** whose top surface now faces upward and backward. The lower lip of the crest meets the lateral border of the acromion (at the outer back corner of the shoulder) and forms the **acromial angle,** which sometimes shows up as a conspicuous bony landmark in life.

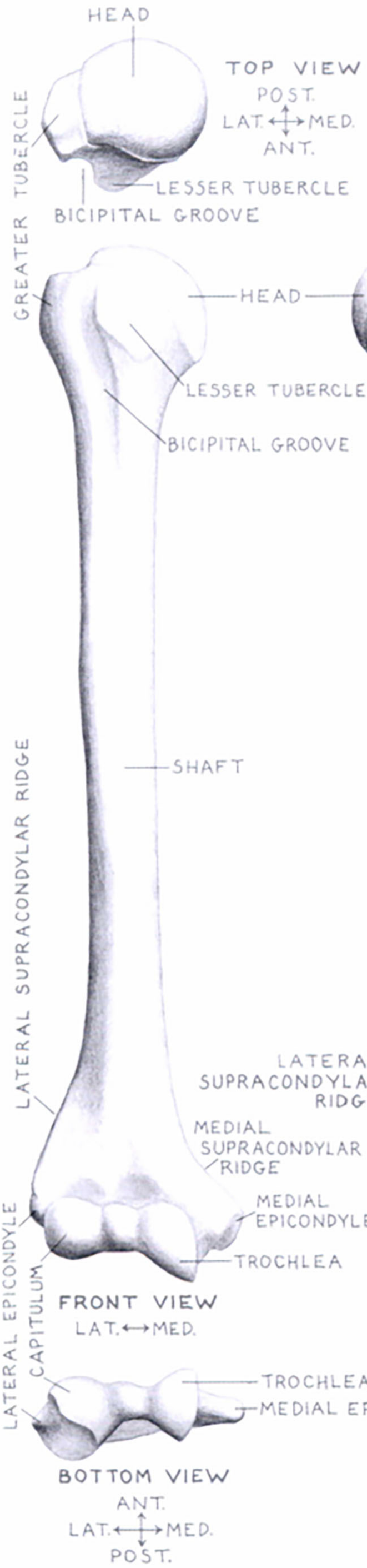
The acromion sits at a level slightly lower than the usually more conspicuous lateral end of the clavicle. Because the lateral end of the clavicle articulates with the *medial* border of the acromion, the *outer* border of the acromion forms the **point of the shoulder,** the most lateral bony point of the shoulder girdle. In side view, the acromion angles forward and upward, hovering shelflike over the posterior part of the top of the head of the humerus. There is a small gap between the head of the humerus and the deep surface of the acromion.

Except for a narrow strip at the outer edge of the acromion's upper surface where the deltoid attaches, the entire spine and the acromion are subcutaneous—no muscles pass over; rather, they are attached to their edges. The spine can be seen as a depressed furrow when the surrounding musculature is developed or as a projecting ridge when the muscles are thin or stretched.

In the normal relaxed shoulder position, the spine is oblique, directed upward and outward. As the arm is raised and the scapula is rotated, the spine approaches the vertical. When the arm has been completely raised above the head, the spine of the scapula is almost in line with the humerus. The width across the shoulders between the outer borders of the acromions is greater than the width across the hips at the outer surfaces of the greater trochanters of the femurs, more so in the male than in the female. The points of the shoulders are widest when the shoulders are thrust forward, because the scapulae have then slid anteriorly and *laterally* over the rounded rib cage.

With the arm down and the shoulder in the relaxed position, the inferior angle is located at the level of the seventh or eighth rib. Relating it to the front of the body, the inferior angle lies about one inch below the level of the nipples, at about the level of the infrasternal notch. The vertebral border may be either vertical, directed slightly downward and outward, or directed slightly downward and inward. It is located near or in line with the angles of the ribs. The distance between the vertebral borders of both scapulae is roughly equal to the width of the neck.

Those areas of the scapula, whether fully subcutaneous or not, that are most evident on the surface in life are the crest of the spine, the acromion, the vertebral border, and the inferior angle.


HEAD
GREATER TUBERCLE
LESSER TUBERCLE
BICIPITAL GROOVE
SHAFT
LATERAL SUPRACONDYLAR RIDGE
MEDIAL EPICONDYLE
CAPITULUM
TROCHLEA
FRONT VIEW
LAT. ↔ MED.
TOP VIEW
POST.
LAT. ↔ MED.
ANT.
LATERAL SUPRACONDYLAR RIDGE
MEDIAL SUPRACONDYLAR RIDGE
LATERAL EPICONDYLE
OUTSIDE VIEW
POST. ↔ ANT.
BACK VIEW
MED. ↔ LAT.
INSIDE VIEW
ANT. ↔ POST.
BOTTOM VIEW
ANT.
LAT. ↔ MED.
POST.

The *HUMERUS* is the upper arm bone. It articulates with the scapula superiorly and with the radius and ulna inferiorly. It is longer than the forearm bones.

The **shaft of the humerus** is cylindrical and curves slightly forward inferiorly; it is surmounted by a sphere and flattened into a triangle at the lower end.

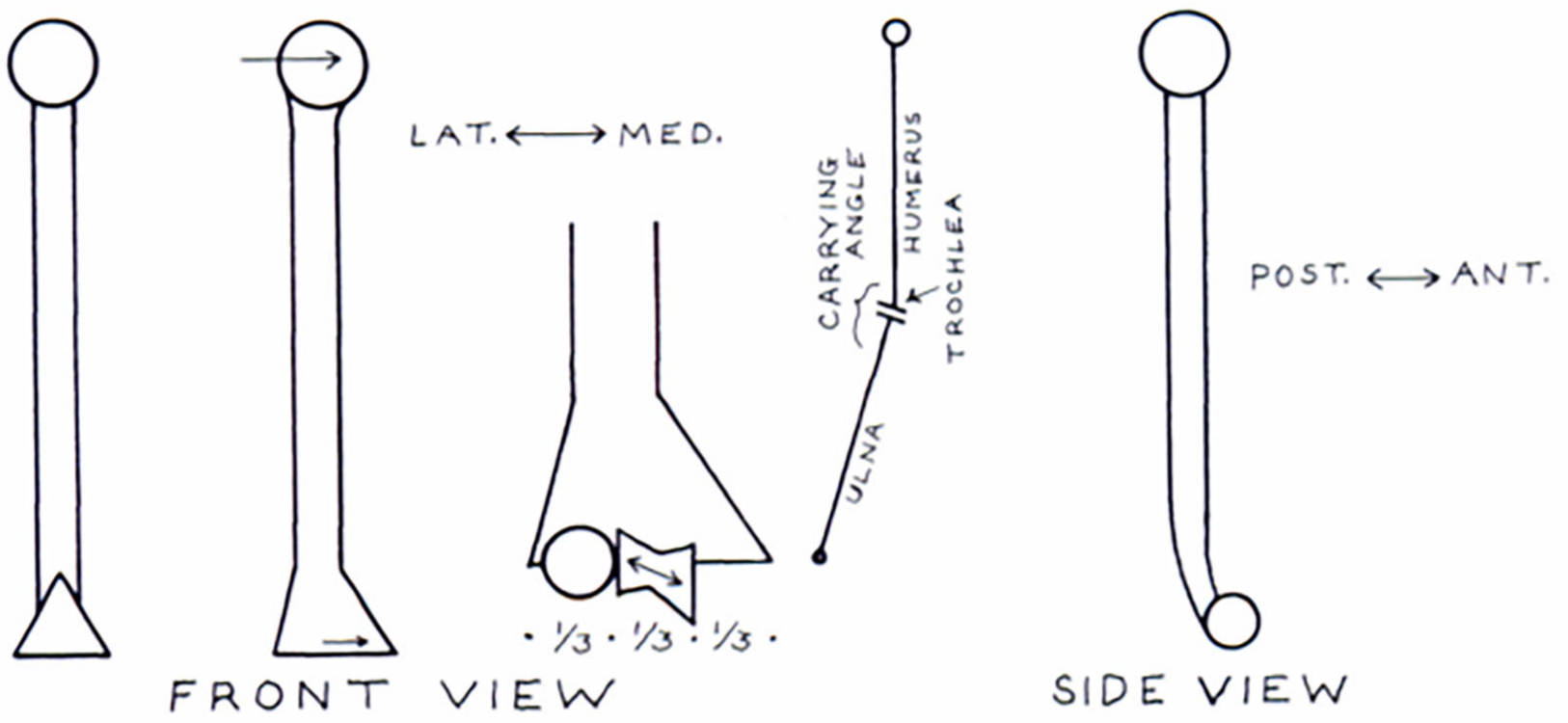
The rounded **proximal extremity** has a hemispherical articular surface, the **head of the humerus,** which is directed medially, superiorly, and posteriorly. The posterior projection of the head causes the rest of the proximal extremity to project forward from the shoulder socket, under the anterior portion of the deltoid muscle, thus influencing surface form. Opposite to the head, the proximal extremity expands into the **greater** and **lesser tubercles.** A vertical furrow, the **bicipital groove,** or intertubercular sulcus, in which the tendon of the long head of the biceps slides, is located between the tubercles.

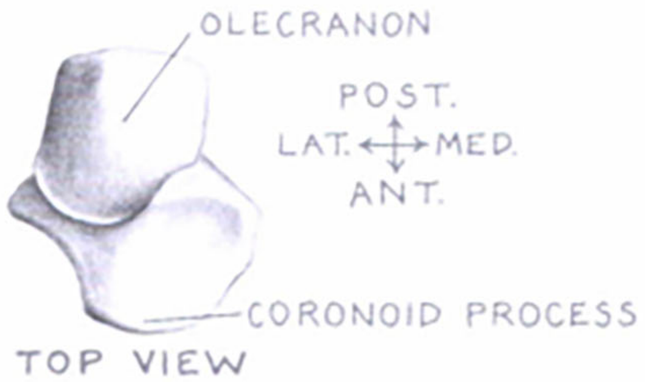
The shaft widens inferiorly to form the **distal expansion.** Its triangular shape is bordered by the **medial** and **lateral supracondylar ridges.** These ridges end at the subcutaneous **medial** and **lateral epicondyles.** In life, because of the muscle mass anterior to the elbow joint, the epicondyles are located toward the back of the elbow region, close to the olecranon process of the ulna. The medial and lateral epicondyles lie at the same level—in the anatomical position the axis through both is horizontal. The medial epicondyle is the larger and more prominent of the two, in the skeleton as well as in life. Locating the medial epicondyle in life and ascertaining the axis through both epicondyles is the key to establishing the orientation of the humerus, and therefore all its muscular origins and insertions. The medial supracondylar ridge is deep and is never seen at the surface. The lateral supracondylar ridge curves forward as it descends (side view). Its lower portion is subcutaneous. The posterior surface of the bone just behind the lateral epicondyle and lateral supracondylar ridge occasionally becomes subcutaneous when the elbow is extended (the triceps slides away). When the elbow is extended and the forearm is supinated, the lateral epicondyle sits in a depression on the outside of the elbow (the **condyloid depression**). The depression between the medial epicondyle and the olecranon contains the easily palpated ulnar nerve.

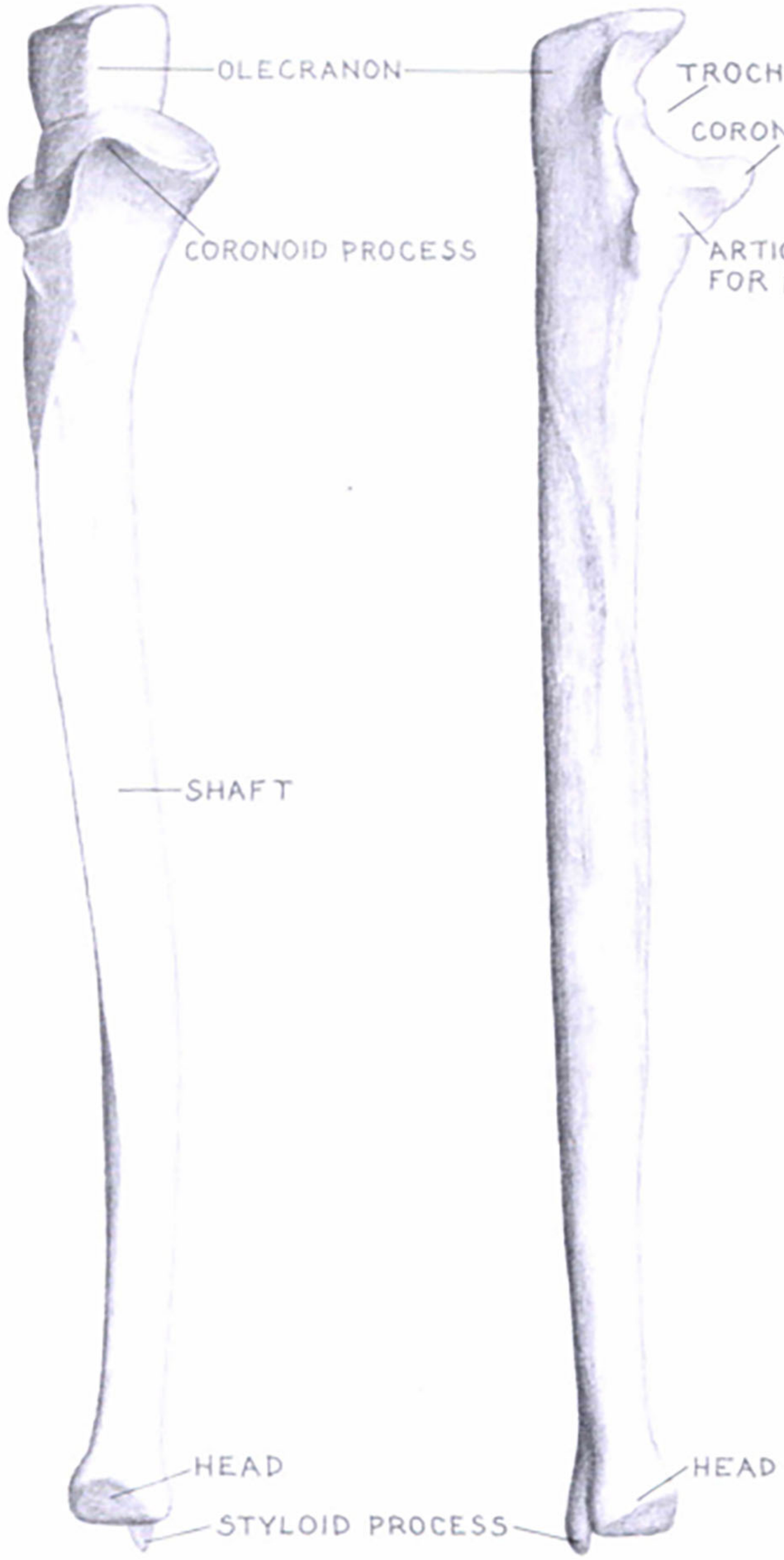
At the distal end of the humerus, projecting anteriorly, are the capitulum and the trochlea. The rounded **capitulum** articulates with the radius. When the elbow is fully flexed, the bottom of the capitulum becomes visible just lateral to the olecranon as the head of the radius glides off its distal surface. The capitulum then lies under only the thin muscular layer of the stretched anconeus and triceps.

The spool-shaped **trochlea** articulates with the ulna. The axis of the trochlea is directed medially and slightly downward. Because the medial half of the spool is larger, its downward projection is increased, thus causing the ulna to angle outward when the elbow is extended. The obtuse angle formed on the outside of the elbow is the **carrying angle.** Anteriorly, just above the trochlea is a notch for the coronoid process of the ulna; the larger and deeper posterior notch receives the olecranon.

Most of the humerus lies deeply buried within the surrounding musculature. Its subcutaneous areas are the medial and lateral epicondyles, the lower portion of the lateral supracondylar ridge, and occasionally the posterior surface just behind this ridge.

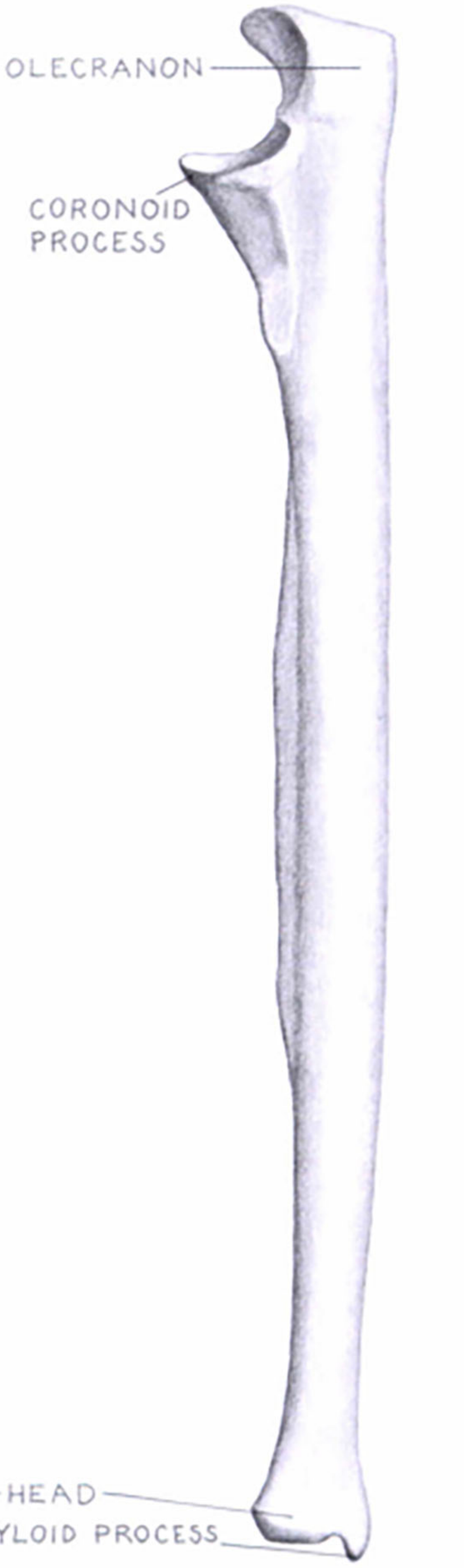


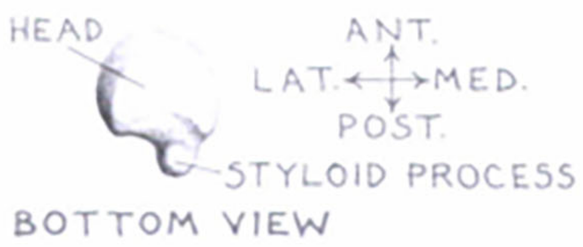

OLECRANON
POST.
LAT. MED.
ANT.
CORONOID PROCESS
TOP VIEW


OLECRANON
CORONOID PROCESS
SHAFT
HEAD
STYLOID PROCESS
FRONT VIEW
LAT. MED.

TROCHLEAR NOTCH
CORONOID PROCESS
ARTICULAR SURFACE FOR RADIUS
HEAD
OUTSIDE VIEW
POST. ANT.

OLECRANON
HEAD
STYLOID PROCESS
BACK VIEW
MED. LAT.


OLECRANON
CORONOID PROCESS
HEAD
STYLOID PROCESS
INSIDE VIEW
ANT. POST.


HEAD
ANT.
LAT. MED.
POST.
STYLOID PROCESS
BOTTOM VIEW

The *ULNA* lies on the medial side of the forearm when the forearm is supinated (in the anatomical position). Its distal end becomes lateral during pronation as the distal end of the radius moves medially, but its proximal end, at the elbow, always remains medial, regardless of whether the forearm is pronated or supinated. The ulna therefore does not participate in pronation or supination—it only flexes and extends at the elbow joint. It is slightly longer than the radius. Unlike the radius, it is larger at its proximal end and smaller at its distal end. In the back view, from above to below, the ulna has an elongated S-shaped curve—first curving laterally, then medially.

The upper three-fourths of the **shaft** is triangular in cross section, while the lower fourth is cylindrical.

The large **proximal expansion** articulates with the humerus. It consists of the blocklike **olecranon** and the **coronoid process.** The radius articulates with the ulna at a small notch just below the trochlear notch.

As the elbow is flexed, the triceps tendon comes to lie against the upper (top) surface of the olecranon, causing it to appear as a prominent bump. However, this surface is not seen when the elbow is extended, because the taut triceps tendon attaches to the upper *back* edge of the olecranon. When the elbow is fully extended, the olecranon is concealed by a layer of loosely bunched skin. Its back edge lies at the same level as the axis running through the medial and lateral epicondyles of the humerus. As the elbow is flexed, the olecranon drops down in relation to this axis.

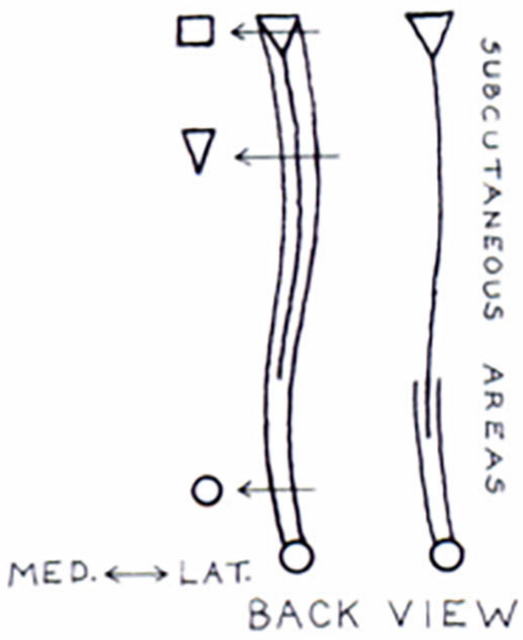
The subcutaneous posterior surface of the olecranon is triangular in shape (its apex directed downward). It is continuous inferiorly with the sharp edge of the posterior border of the shaft. The posterior border, ending three-fourths of the way down the bone, reflects the S-shaped curve of the overall bone (the upper lateral curve allows for a large mass of flexor muscles). Although the middle third of the posterior border is subcutaneous (no muscles cross the entire posterior border of the ulna), it sits at the bottom of a groove, the **ulnar furrow,** created by the bulging masses of flexor and extensor muscles on either side. Continuing distally, the sharp edge of the posterior border blends into the cylindrical portion of the shaft.

Distally, the shaft expands into the spherical **head of the ulna.** The **styloid process** extends inferiorly from the posterior surface of the head; it is not visible on the surface. The posterior surface of the head is grooved for the tendon of the extensor carpi ulnaris. Because the ulna is limited to flexion and extension at the elbow, during pronation and supination of the forearm, *the head of the ulna does not rotate around its long axis, nor does it move side to side through motion at the elbow joint.*

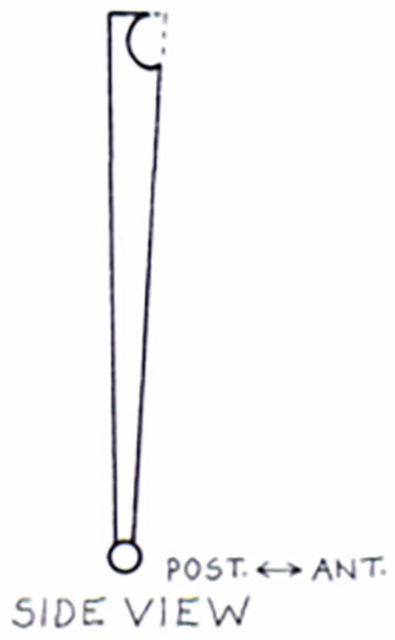
Different surface areas of the head become exposed during pronation and supination as the radius rotates around the head of the ulna, and the relationship of the tendon of the extensor carpi ulnaris to the distal end of the radius also changes (see "Extensor carpi ulnaris"). The head is most prominent when the forearm is pronated and is hardly seen in full supination.

The inferior surface of the head does not directly touch the carpal bones, but articulates via a triangular fibrous disc. The disc connects the styloid process of the ulna to the radius. The articulation of the hand with the ulna is therefore minimal and weak; it is the articulation of the hand with the radius that is the major joint of the wrist. The head of the ulna articulates in a notch on the medial surface of the distal end of the radius. The distal end of the ulna is always associated with the little-finger side of the hand.

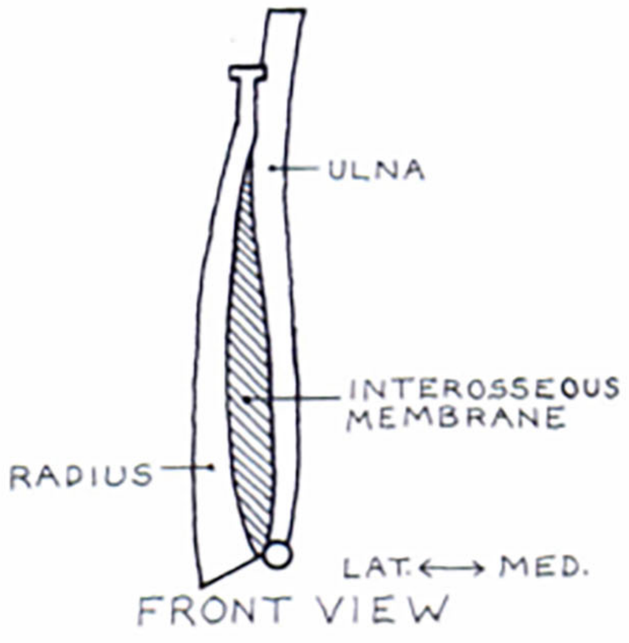
An **interosseous membrane** is located in the space between the radius and the ulna, attached to their inner edges. Muscles originate on both the anterior and posterior surfaces of the membrane.



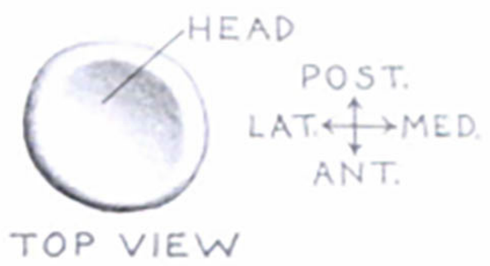
BACK VIEW



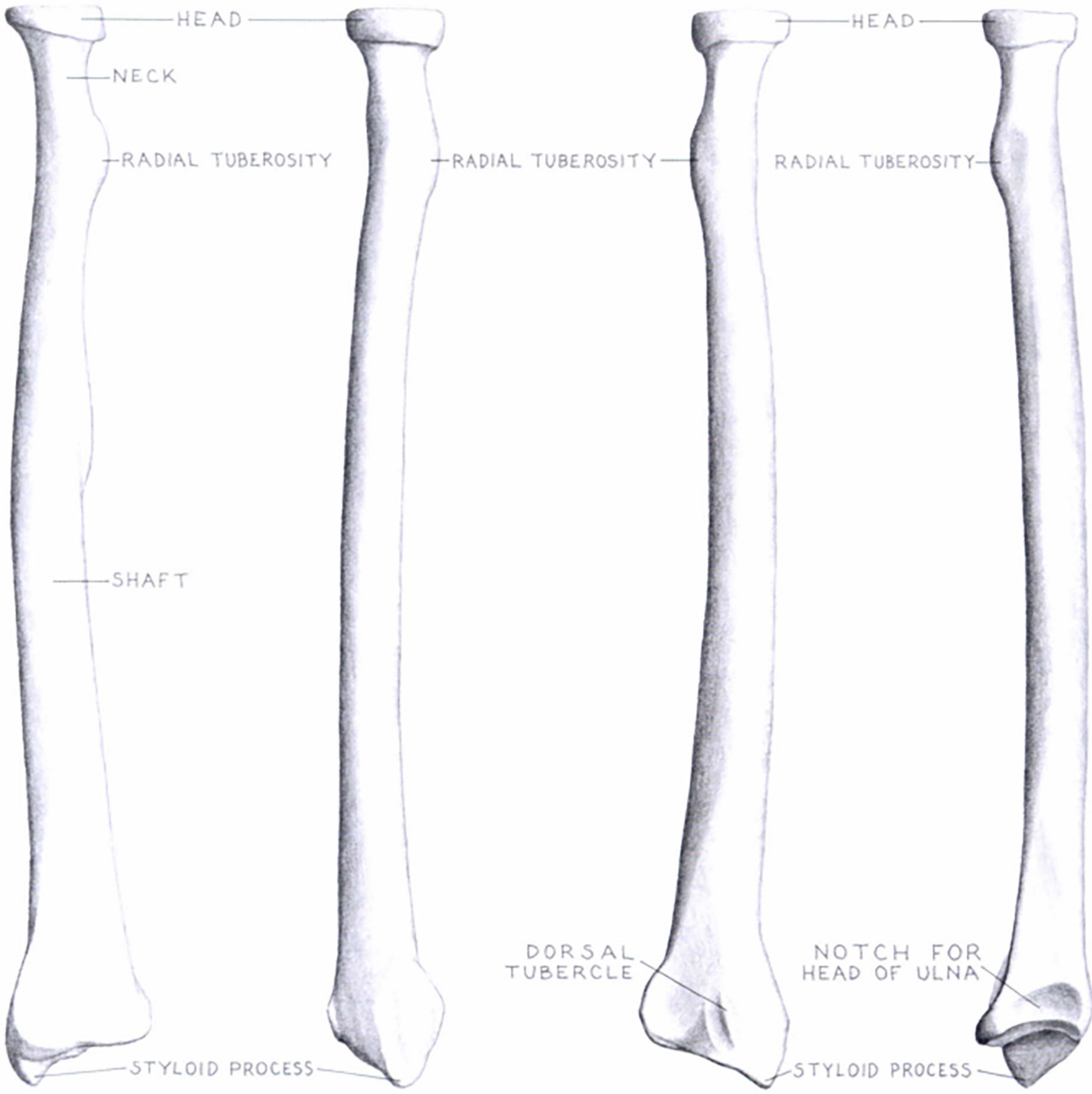
SIDE VIEW



FRONT VIEW



TOP VIEW

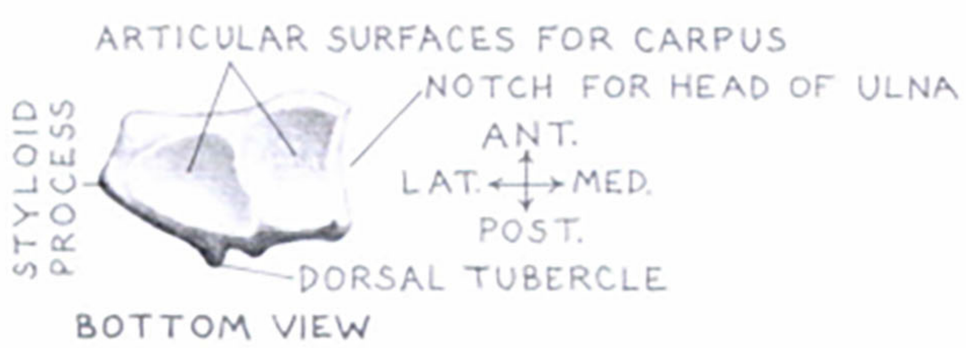


FRONT VIEW
LAT. ↔ MED.

OUTSIDE VIEW
POST. ↔ ANT.

BACK VIEW
MED. ↔ LAT.

INSIDE VIEW
ANT. ↔ POST.



BOTTOM VIEW

The *RADIUS* is the lateral bone of the forearm when the forearm is supinated and in the anatomical position. It is then parallel to the ulna. The radius, not the ulna, rotates during pronation and supination, and it assumes an oblique position across the ulna when the forearm is pronated. The proximal end of the radius is always located on the lateral side of the elbow joint, and its distal end, enlarged to articulate with the hand, rotates around the distal end of the ulna. The distal end of the radius is always associated with the thumb side of the hand. The radius is slightly shorter than the ulna, and it is displaced distally in relation to the ulna, so that the radius descends further at the wrist. The proximal end of the radius articulates with the humerous superiorly and with the ulna laterally; its distal end articulates with the carpal bones inferiorly and with the ulna medially.

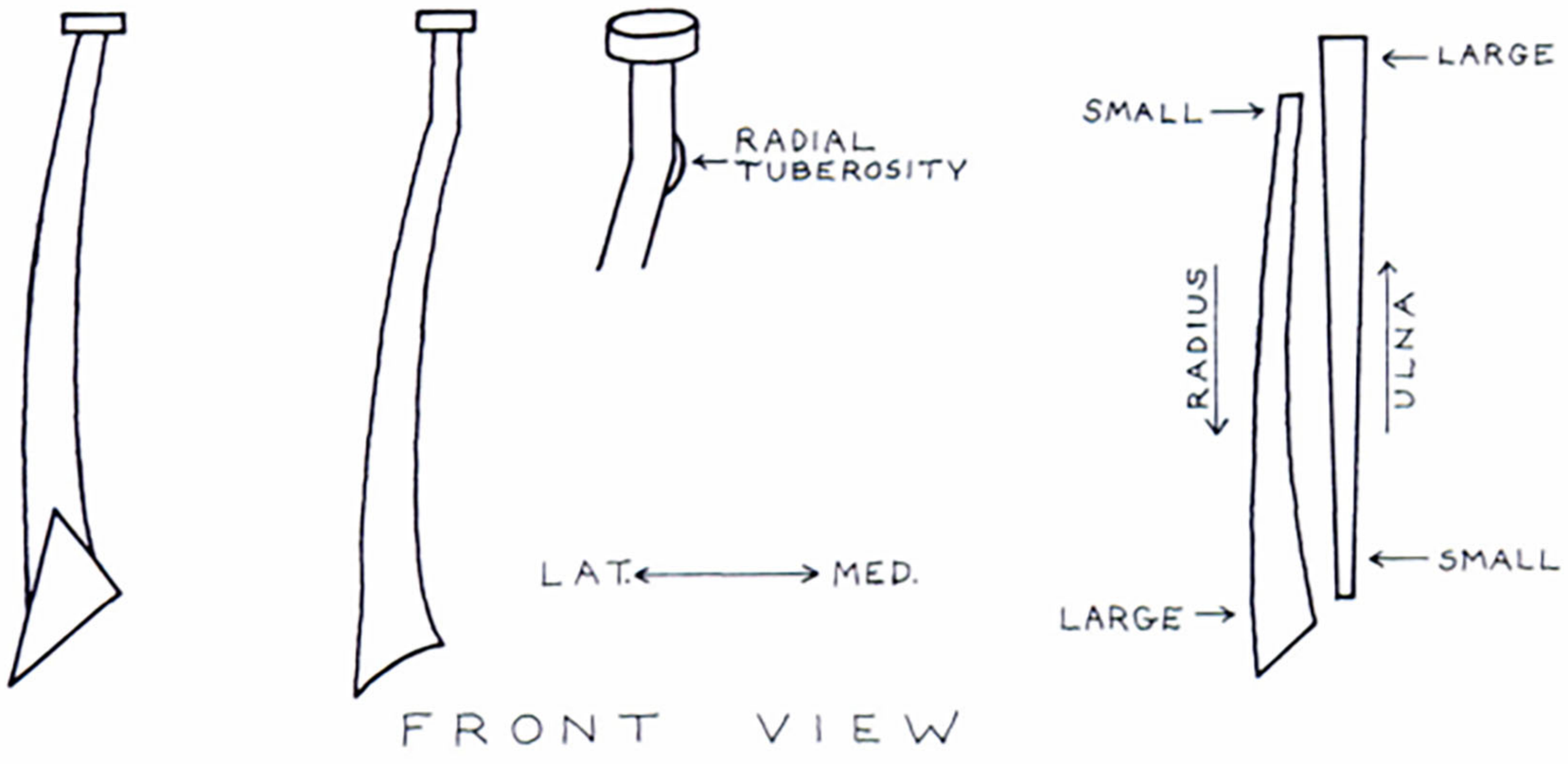
The **shaft,** narrow above and becoming increasingly larger below, is cylindrical in its proximal two-thirds; it then begins to widen side to side and flatten front to back. From its superior end, the shaft descends straight down for a very short distance as the **neck,** expanding into the **radial tuberosity** on its medial surface. The remainder of the shaft has a gentle, laterally convex curve (curving the axis of the bone away from the axis of pronation and supination, thereby giving the pronator teres muscle greater mechanical advantage). The lateral surface of the distal half of the shaft, for the most part lying under thin tendons, is a strong determinant of surface form. The rest of the shaft is buried deep in muscle.

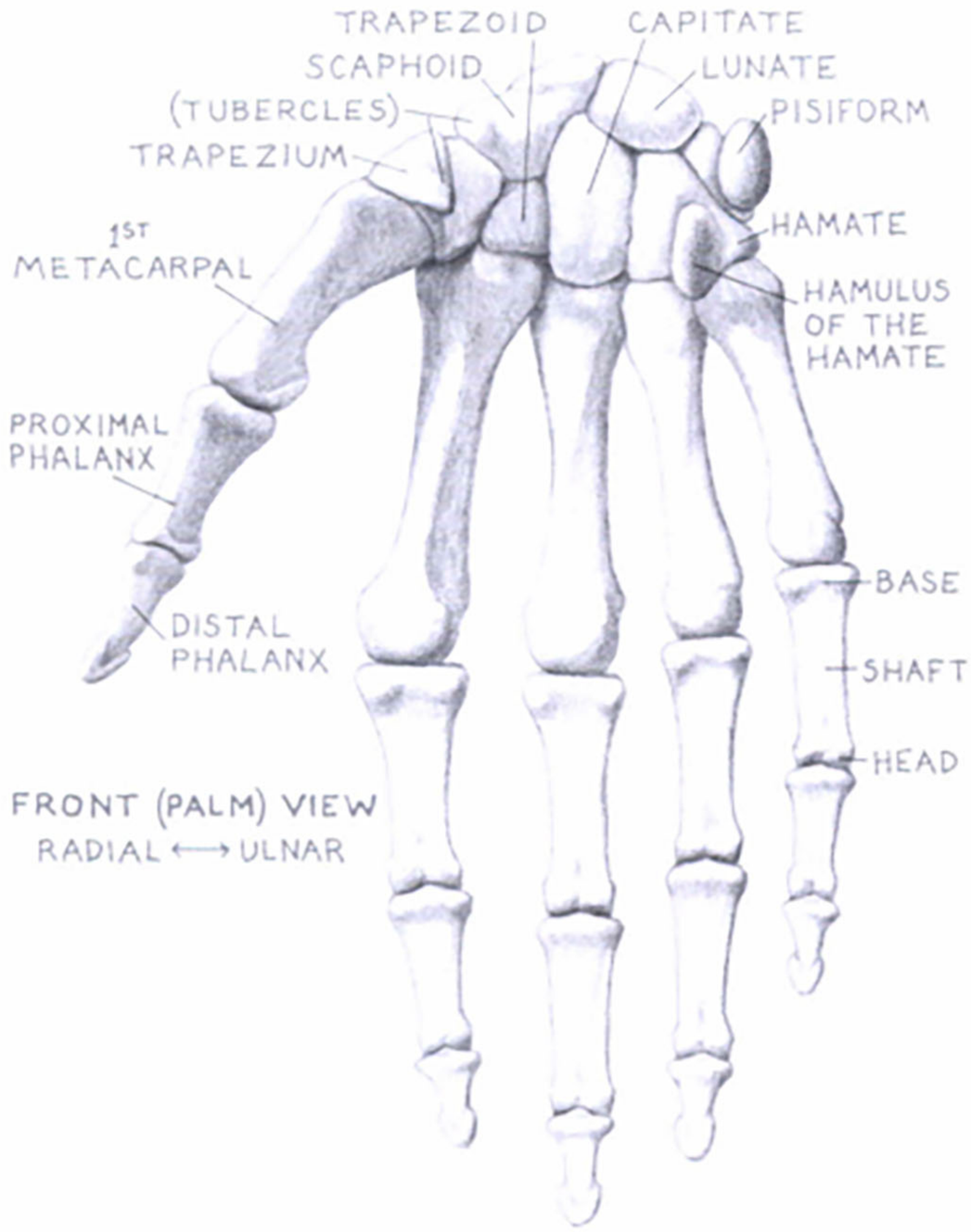
Superiorly, the bone expands into the **head of the radius,** a horizontal disclike form with a shallow concavity on its upper surface. It articulates with the rounded capitulum of the humerus. The head, situated just distal to the lateral epicondyle of the humerus (not truly subcutaneous as it lies under the thin superior end of the extensor carpi ulnaris), is easily palpated. When the elbow is extended and the forearm pronated, the small **dimple of the elbow** forms on the outside of the elbow between the head of the radius and the capitulum of the humerus. When the elbow is extended and the forearm supinated, the head of the radius lies in a fairly large depression, the **condyloid depression,** created by the bulging forms of the surrounding musculature.

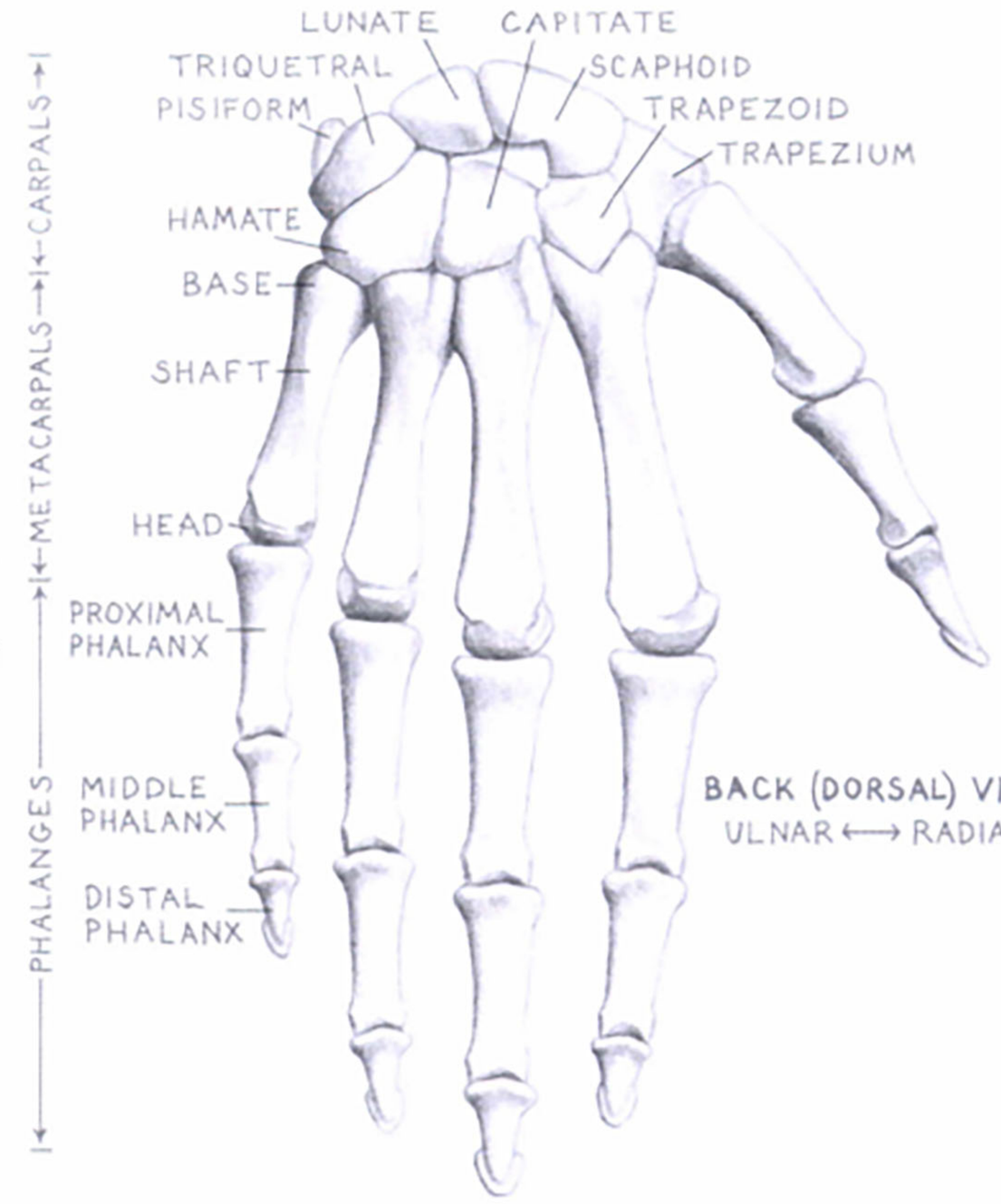
The **distal end** of the radius expands into an irregular flattened form, wider than it is deep and rectangular in cross section. It helps establish the blocklike nature of the wrist. Its distal surface is triangular and concave, creating the curved socket of the wrist joint into which the carpal bones articulate. The distal expansion of the radius is notched on its medial surface to receive the head of the ulna. Its lateral side is prolonged inferiorly by a pointed bony projection, the **styloid process,** which extends further distally than the styloid process of the ulna.

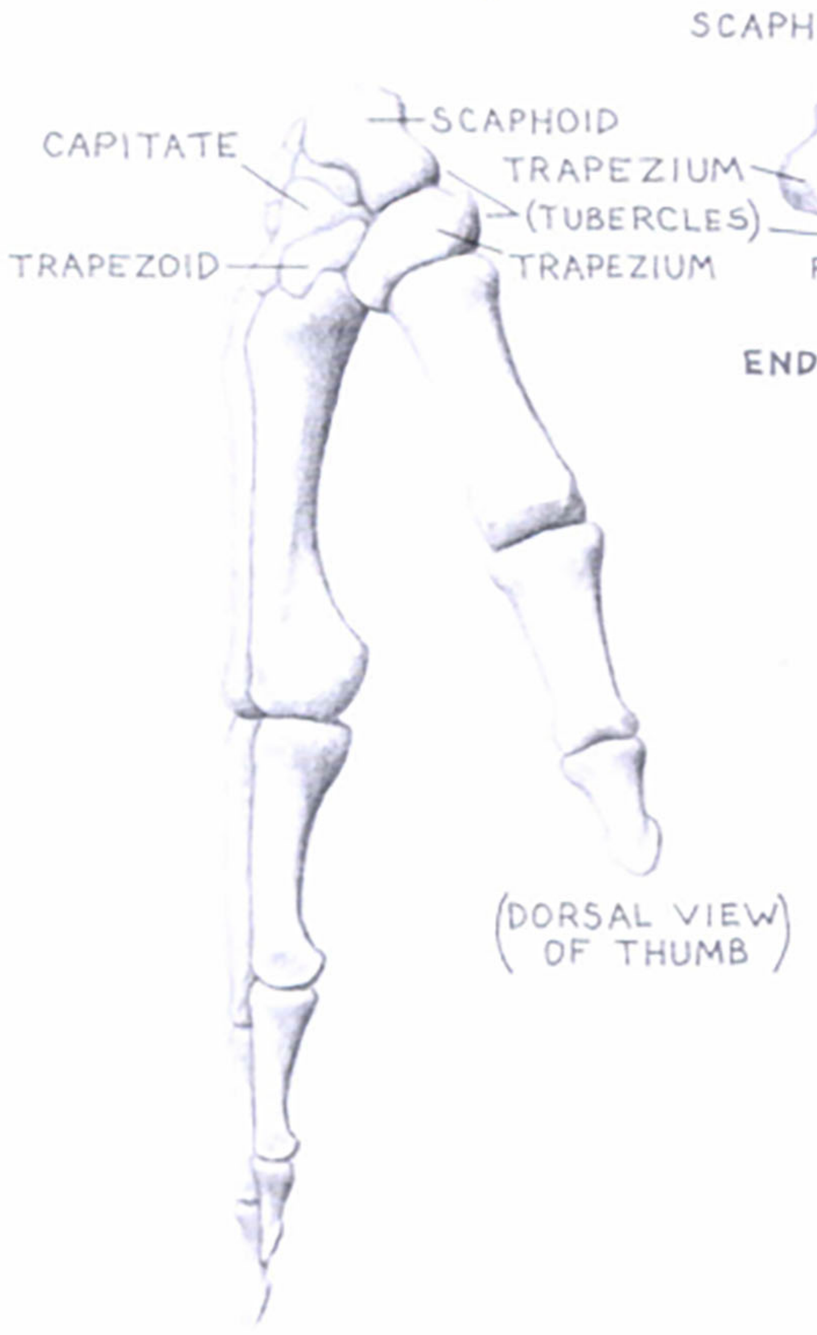
The lateral and posterior surfaces of the distal extremity of the radius, covered only by tendons, are easily palpable. The posterior surface is slightly convex, while its deep anterior surface is slightly concave. The **dorsal tubercle** is a short, raised, vertical bony ridge located on the middle of the posterior surface.

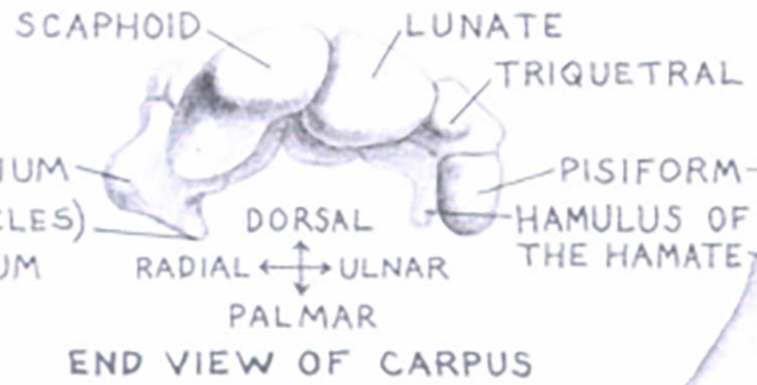
The diameters of the radius and ulna are roughly equal at a point halfway down each bone.



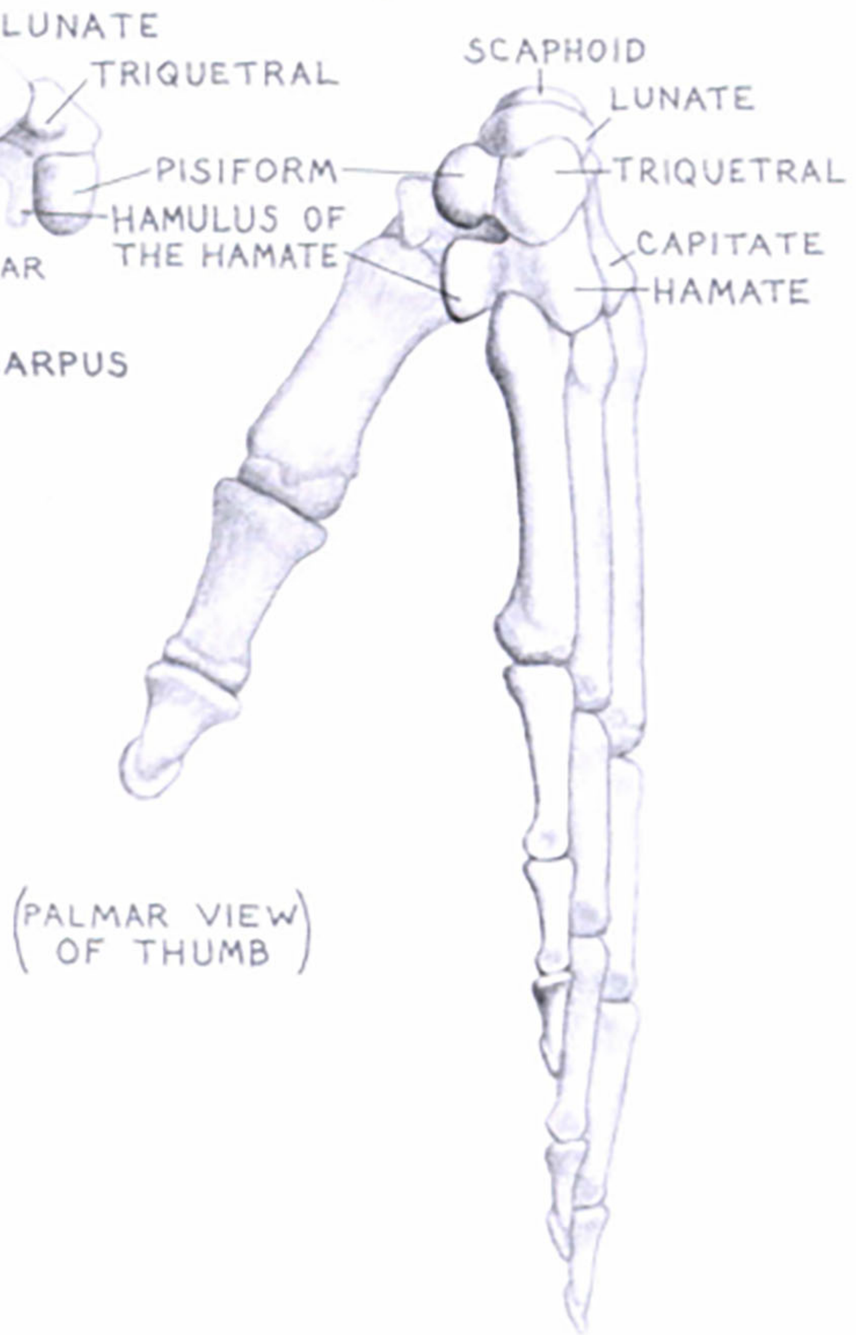

TRAPEZOID
CAPITATE
SCAPHOID
LUNATE
(TUBERCLES)
PISIFORM
TRAPEZIUM
HAMATE
1ST METACARPAL
HAMULUS OF THE HAMATE
PROXIMAL PHALANX
BASE
SHAFT
DISTAL PHALANX
HEAD
FRONT (PALM) VIEW
RADIAL ⟷ ULNAR


LUNATE
CAPITATE
TRIQUETRAL
SCAPHOID
PISIFORM
TRAPEZOID
TRAPEZIUM
HAMATE
BASE
SHAFT
HEAD
PROXIMAL PHALANX
MIDDLE PHALANX
DISTAL PHALANX
BACK (DORSAL) VIEW
ULNAR ⟷ RADIAL
I←METACARPALS→I←CARPALS→I
I←PHALANGES→I


SCAPHOID
CAPITATE
TRAPEZIUM
(TUBERCLES)
TRAPEZOID
TRAPEZIUM
I←METACARPALS→I←CARPALS→I
I←PHALANGES→I
THUMB SIDE (RADIAL VIEW)
DORSAL ⟷ PALMAR


SCAPHOID
LUNATE
TRIQUETRAL
TRAPEZIUM
(TUBERCLES)
TRAPEZOID
TRAPEZIUM
DORSAL
RADIAL ⟷ ULNAR
PALMAR
END VIEW OF CARPUS

(DORSAL VIEW OF THUMB)


SCAPHOID
LUNATE
TRIQUETRAL
PISIFORM
HAMULUS OF THE HAMATE
CAPITATE
HAMATE
(PALMAR VIEW OF THUMB)
LITTLE FINGER SIDE (ULNAR VIEW)
PALMAR ⟷ DORSAL

The *SKELETON OF THE HAND* is designed to perform the most heavy brutal chores, as well as extremely precise, sensitive, and delicate movements. In life, the hand is predominantly bony, with its surface form based for the most part on its skeleton, especially its back or dorsal surface. It consists of the carpus, the metacarpus, and the phalanges. The phalanges together are longer than the metacarpals, which in turn are longer than the carpals. These proportions are opposite to those found in the foot between the tarsals, metatarsals, and phalanges.

The *CARPUS* consists of eight small irregularly shaped **carpal bones** arranged in two rows—a proximal and a distal—of four bones each. The proximal row contains the **scaphoid, lunate, triquetral,** and **pisiform.** The distal row contains the **trapezium, trapezoid, capitate,** and **hamate.** As a unit, the carpal bones form half a disc which is curved side to side, so that its dorsal surface is convex; the concave palmar surface is transformed into the **carpal tunnel** for passage of the flexor tendons to the fingers.

On the back of the carpus, between the two carpal rows, is a depression (located toward the radial side). It is especially noticeable when the wrist joint is flexed. Also noticeable in this position is another depression between the distal end of the radius and the proximal carpal row (the articulating proximal surface of the carpus becomes a raised prominence between the two depressions).

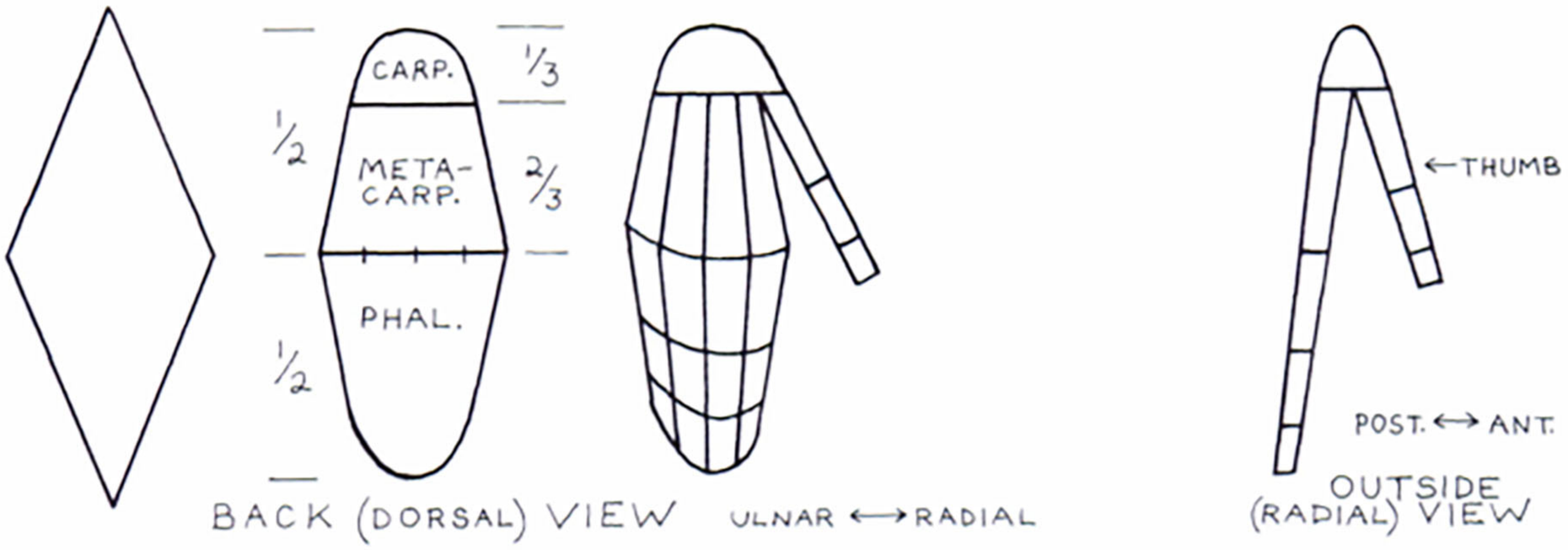
On the palmar side of the carpus, bony prominences are formed by the pisiform at the ulnar side (at the base of hypothenar eminence) and by the tubercles of the trapezium and scaphoid together on the radial side (at the base of the thenar eminence). These bony projections are especially noticeable when the wrist joint is extended.

At the wrist joint, the arched proximal carpal row articulates primarily with the distal end of the radius and minimally with the fibrous disc attached to the distal end of the ulna.

The *METACARPUS* consists of the five **metacarpal bones.** The boxlike **base** of each bone is located at the proximal extremity of the **shaft,** while the rounded **head** is located at the distal extremity. Metacarpals two through five (index to little finger) as a group radiate distally. The dorsal surfaces of the metacarpals are wide and flattened, especially distally, and all have a slight convex curvature. Metacarpals two through five create a plane on the back of the hand that curves side to side; it is especially noticeable at the knuckles. This curve, or **transverse arch,** helps create the concavity of the palm. The curvature of the transverse arch flattens when the open hand is pressed against a flat surface.

Distally, the heads of metacarpals two through five are connected to each other by ligaments; the head of the thumb is unattached, allowing it to have a great range of motion at the carpometacarpal joint and the ability to oppose the other fingers in grasping. The thumb's metacarpal is rotated around its long axis so that its dorsal surface faces laterally when the palm is directed forward (its dorsal surface is almost perpendicular to the dorsal surfaces of the other metacarpals).

The heads of metacarpals two through five are somewhat spherical. Their distal surfaces become exposed in life as rounded knuckles when the fingers are flexed at the metacarpophalangeal joints. These four metacarpals end distally along a curved line, with the middle finger projecting the farthest. The width across these four metacarpal heads is greater than the width across the humeral epicondyles at the elbow. Because the thumb's metacarpal head is not as rounded as the others, and because of limited motion at the metacarpophalangeal joint of the thumb, the distal surface of this metacar-



pal does not create a rounded knuckle. Two **sesamoid bones** are located on the palmar surface of the thumb's metacarpal head; in side view, they increased the thickness of this area from front to back.

A small tubercle is present on the lateral side of the base of the metacarpal of the little finger. Because of its slight projection, a subtle depression forms between it and the triquetral of the carpus. Another slight depression is located proximally between the triquetral and the head of the ulna; in other words, there are three little bumps on the ulnar side of the wrist—the head of the ulna, the triquetral, and the tubercle of the fifth metacarpal—separated by two slight depressions.

The fingers are made up of the *PHALANGES* (singular: **phalanx**). The thumb has only two phalanges, a proximal and a distal, while each of the other fingers has three—a proximal, a middle, and a distal. Their **shafts** taper distally, and their proximal **bases** are wider than their distal **heads.** On a given finger, the length of each phalanx diminishes distally. The distal extremities of all the proximal and middle phalanges are squared-off, with a shallow central groove separating the medial and lateral condyles of their spool-shaped heads. This squared-off, notched shape is seen on the surface in life when the interphalangeal joints are flexed. The tips of all five distal phalanges are flattened. The fingernails attach to the dorsal surface of the flattened areas via a thick fibrous padding. The tips of the distal phalanges are embedded in the fibrous fat of the fingertips.

The side-to-side narrowing of the shafts of the proximal phalanx of the thumb and the middle phalanges of the other four fingers is seen on the surface in life.

The middle finger is the longest finger; next longest is the ring finger, then the index finger (sometimes it is as long as the ring finger), and then the little finger. The thumb is considerably shorter. The length of the three phalanges together of the index finger is equal to the width across the heads of metacarpals two through five. The combined lengths of both the middle and distal phalanges of a finger approximately equals the length of its proximal phalanx. The metacarpophalangeal joint of the middle finger is the midpoint of the length of the skeleton of the hand.

The complete *PELVIS* consists of both hip bones, the sacrum, and the coccyx. These components form a rigid bony ring. The **pelvic girdle** is made up of the hip bones of both sides of the body. Each **hip bone** (**innominate** or **haunch bone**) is made up of three bones—the ilium, ischium, and pubis—that fuse together early in life, leaving little indication of their individual identities in the adult. They meet at the middle of the side of the hip bone and form the **acetabulum,** the deep, cup-shaped hip socket. The acetabulum receives the round head of the femur. The hip bones are rigidly united to each other at the pubic symphysis in front and to the sacrum in back.

The *ILIUM* is the large upper platelike bone. Both iliac bones converge toward the back.

The thickened upper edge of the ilium is called the **iliac crest.** The outer edge of the crest is the **outer lip.** The crest begins in front at an important bony landmark, the **anterior superior iliac spine** (ASIS), also referred to as the **front point of the pelvis.** The crest ends in back at the enlarged **posterior superior iliac spine** (PSIS), or **back point of the pelvis.** The front point does not protrude much because muscles originate and then descend from its tip. It does become more prominent when the vertebral column is extended (in leaning backward). The front point lies on the same vertical plane as the front edge of the pubic symphysis. The back point is surrounded by bulging muscle (and sometimes fat, especially in the female), where it forms a dimple. When the spine is completely flexed forward, the back point appears as a raised projection. Because of the greater width of the female pelvis and sacrum, the dimples of the posterior points are relatively farther apart in the female than in the male. The distance between the two back points is approximately equal to one-third the greatest width of the pelvis. The back point is usually located slightly above the level of the front point.

Situated at the upper front edge of the lip of the acetabulum, the **anterior inferior iliac spine** (AIIS) is located below and medial to the front point and is separated from it by a notch. The **posterior inferior iliac spine** (PIIS) is found a couple of inches directly below the back point. The inferior spines in front and in back are deep and do not influence surface form. The anterior point is an important site for muscle attachment (the rectus femoris).

At its simplest, the **iliac crest** curves upward in an arc of a circle, beginning at the front point and ending at the back point. It also may have less curvature and more angularity; from the front point of the pelvis, the crest curves upward and backward, and approximately two-thirds of the way back it changes direction at the **highest point** of the pelvis and then curves downward and backward. The crest therefore varies in individuals from having a single continuous circular arc to having a sharp and angular change of direction within its curvature.

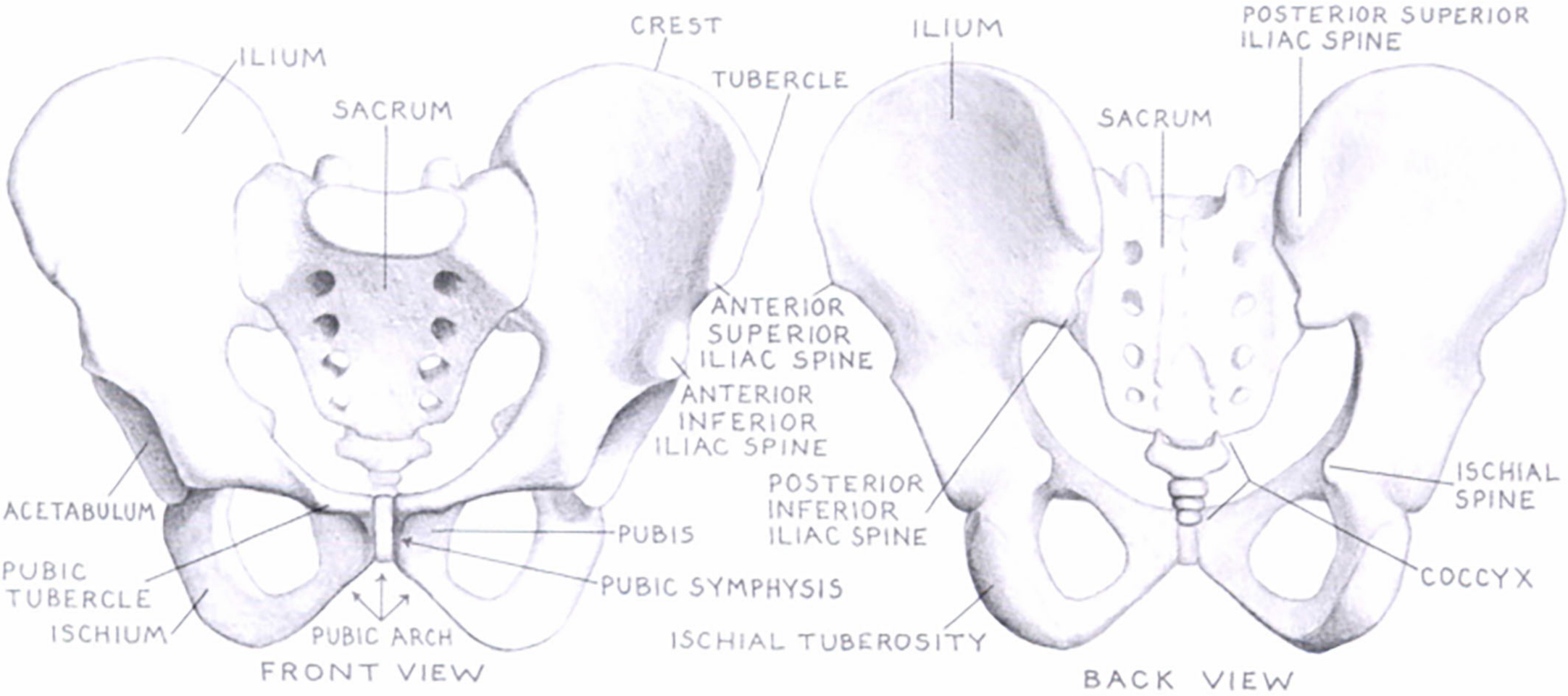
In the normal standing position, only the anterior fourth of the crest is subcutaneous and visible. The outer lip of the crest may show up as a downward curving sharp edge, or the whole thickness of the crest may appear as a narrow, elongated, downward curving form. The posterior three-fourths of the crest is concealed as the form of the flank pad descends over it (see "External oblique"). When the thorax is bent laterally to one side at the lumbar vertebrae, the flank pad of the opposite side rises and is stretched, exposing the middle portion of the outer lip of the iliac crest.

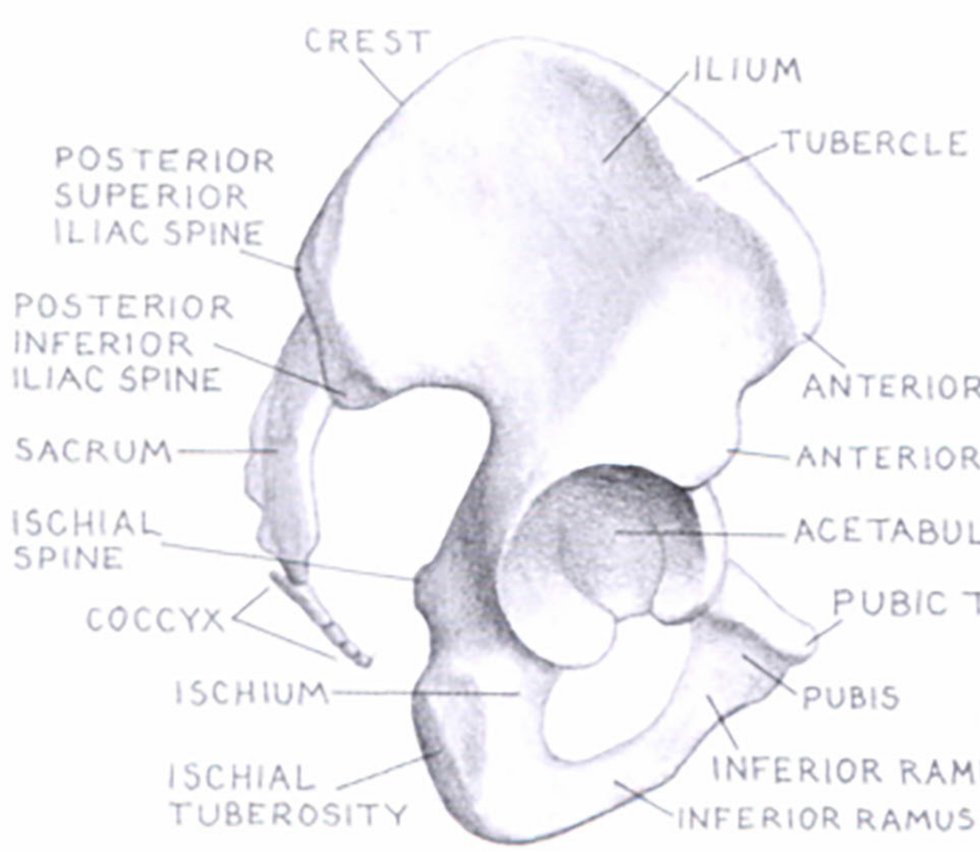
Viewed from the top, the iliac crest forms an S curve. Beginning at the front point of the pelvis, the crest passes outward and backward for a short distance (straight or concave on its outer edge), then inward and backward (its longest section), and then almost straight back for its shortest length to end at the back point of the pelvis (these two short lengths converge posteriorly). The anterior change of curvature takes place at the **widest point** of the pelvis, at the location of the **tubercle.** The tubercle is easily palpated in life and is often visible. The posterior change of direction is the **reentering angle.** The reentering angle itself is covered by the fat of the posterior end of the flank pad.

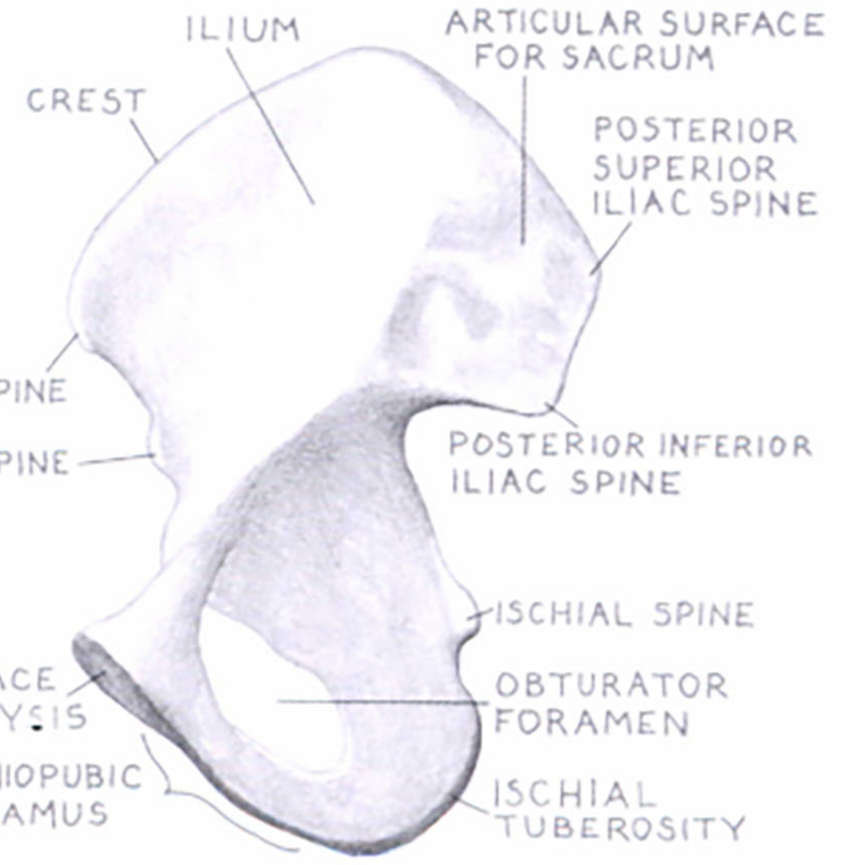
The *PUBIS,* or pubic bone, meets its fellow of the opposite side at the midline in front. They are separated by a fibrocartilaginous disc. This junction is called the **pubic symphysis.** The top edge of the symphysis, located on the same vertical plane as the front points of the pelvis, is covered and concealed by the pubic fat and the upper margin of the pubic hair. It lies at the same level as the inferior tip of the coccyx. The midpoint of the figure is located approximately at the level of the pubic symphysis.

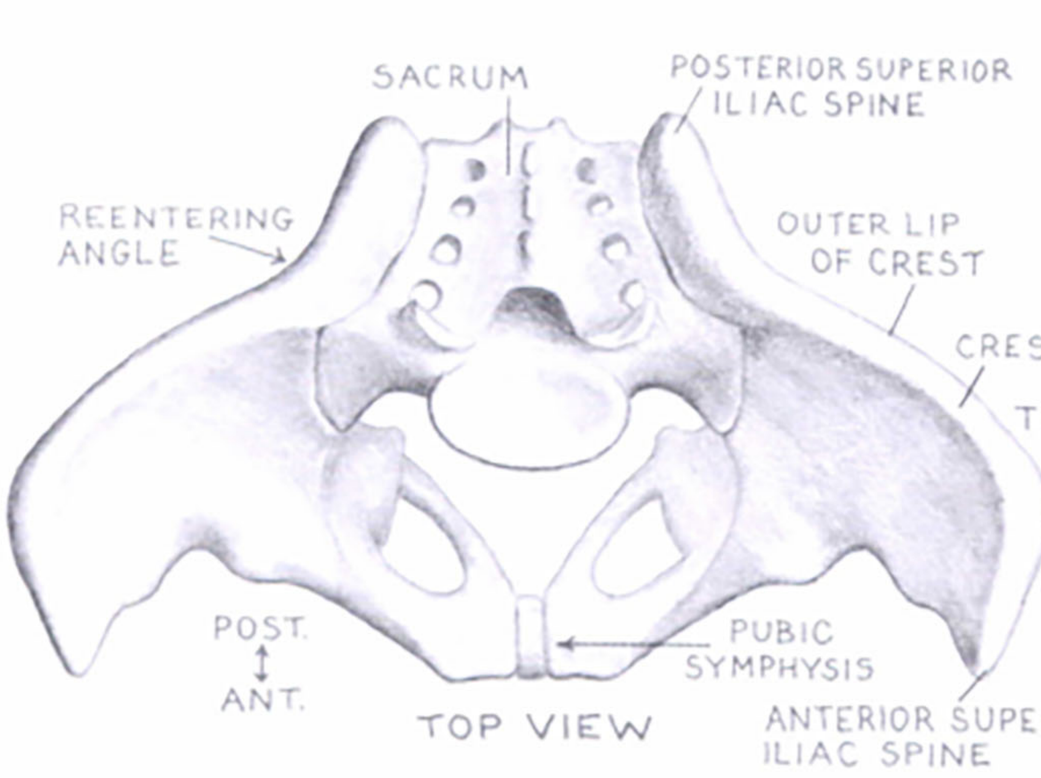
The **pubic tubercle** is located a short distance to the side of the midline, at the top edge of the pubic bone. The thin narrow portion of the pubic bone that passes downward, backward, and outward from the bottom of the pubic symphysis, reaching halfway to the ischial tuberosity (and continuous with the ramus of the ischium), is the **inferior ramus of the pubis.** The inferior rami of both sides form the **pubic arch.**

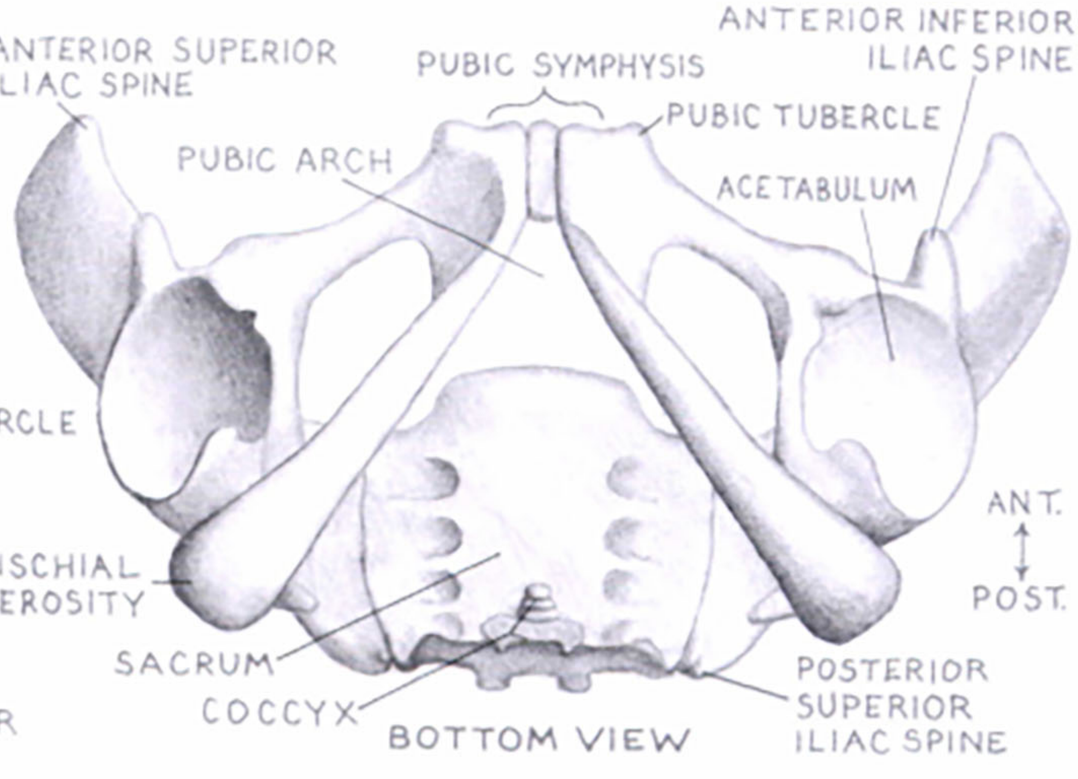
The *ISCHIUM* forms the lower back portion of the pelvis. It is primarily made up of the **ischial tuberosity,** a thick, strong, bony swelling that supports the body's weight in the sitting position and provides attachment areas for the hamstring muscles. The distance between the two ischial tuberosities (measuring from their


ILIUM
SACRUM
CREST
TUBERCLE
ANTERIOR SUPERIOR ILIAC SPINE
ANTERIOR INFERIOR ILIAC SPINE
ACETABULUM
PUBIS
PUBIC TUBERCLE
PUBIC SYMPHYSIS
ISCHIUM
PUBIC ARCH
FRONT VIEW
ILIUM
POSTERIOR SUPERIOR ILIAC SPINE
SACRUM
ANTERIOR SUPERIOR ILIAC SPINE
POSTERIOR INFERIOR ILIAC SPINE
ISCHIAL SPINE
COCCYX
ISCHIAL TUBEROSITY
BACK VIEW


CREST
ILIUM
TUBERCLE
POSTERIOR SUPERIOR ILIAC SPINE
POSTERIOR INFERIOR ILIAC SPINE
SACRUM
ISCHIAL SPINE
COCCYX
ISCHIUM
ISCHIAL TUBEROSITY
ANTERIOR SUPERIOR ILIAC SPINE
ANTERIOR INFERIOR ILIAC SPINE
ACETABULUM
PUBIC TUBERCLE
PUBIS
INFERIOR RAMUS OF PUBIS
INFERIOR RAMUS OF ISCHIUM
OUTSIDE VIEW
POST. ↔ ANT.
(RIGHT HIP BONE)


ILIUM
ARTICULAR SURFACE FOR SACRUM
CREST
POSTERIOR SUPERIOR ILIAC SPINE
POSTERIOR INFERIOR ILIAC SPINE
ISCHIAL SPINE
OBTURATOR FORAMEN
ISCHIAL TUBEROSITY
ARTICULAR SURFACE AT PUBIC SYMPHYSIS
ISCHIOPUBIC RAMUS
INSIDE VIEW
ANT. ↔ POST.
(RIGHT HIP BONE)


SACRUM
POSTERIOR SUPERIOR ILIAC SPINE
REENTERING ANGLE
OUTER LIP OF CREST
CREST
TUBERCLE
ANTERIOR SUPERIOR ILIAC SPINE
ANTERIOR INFERIOR ILIAC SPINE
ACETABULUM
PUBIC TUBERCLE
PUBIS
ISCHIAL SPINE
COCCYX
ISCHIUM
ISCHIAL TUBEROSITY
POST. ↕ ANT.
PUBIC SYMPHYSIS
TOP VIEW
ANTERIOR SUPERIOR ILIAC SPINE


ANTERIOR SUPERIOR ILIAC SPINE
PUBIC SYMPHYSIS
ANTERIOR INFERIOR ILIAC SPINE
PUBIC TUBERCLE
PUBIC ARCH
ACETABULUM
ANT. ↕ POST.
ISCHIAL TUBEROSITY
SACRUM
COCCYX
POSTERIOR SUPERIOR ILIAC SPINE
BOTTOM VIEW

centers) is equal to one-half the greatest overall width of the pelvis. The **ramus of the ischium** is the thin strip of bone that begins at the bottom of the ischial tuberosity and passes upward, forward, and medially. The combined rami of the ischium and the pubis are called the **ischiopubic ramus.**

Each hip bone can be reduced to two large perpendicular planes—an upper plane made up of the plate of the ilium and a lower plane comprising the pubis and ischium. These two planes meet and twist at the acetabulum. The larger upper **iliac plane** faces outward and backward, whereas the lower plane faces outward, forward, and slightly downward. In side view, the hip bone can be visualized as a *figure eight* or as a propeller. The large upper portion is connected to the sacrum in back, while the lower portion meets its fellow of the opposite side at the midline in front.

The pelvis can be thought of as containing two bowl-shaped cavities: an upper cavity, open in front, formed by the inner surfaces of the iliac bones and the top of the sacrum (the **greater** or **false pelvis**) and a lower cavity, more enclosed, formed by the inner surfaces of the pubis, ischium, sacrum, and coccyx (the **lesser** or **true pelvis**).

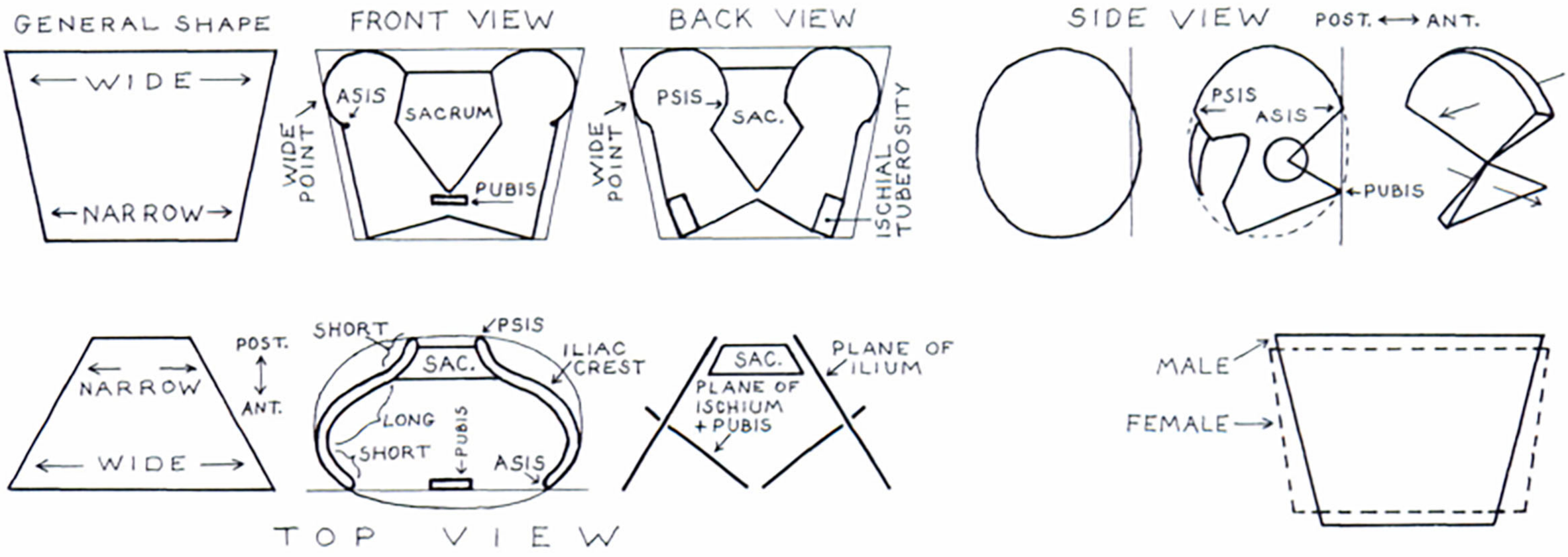
Differences between Male and Female Pelves, Related to Surface Form

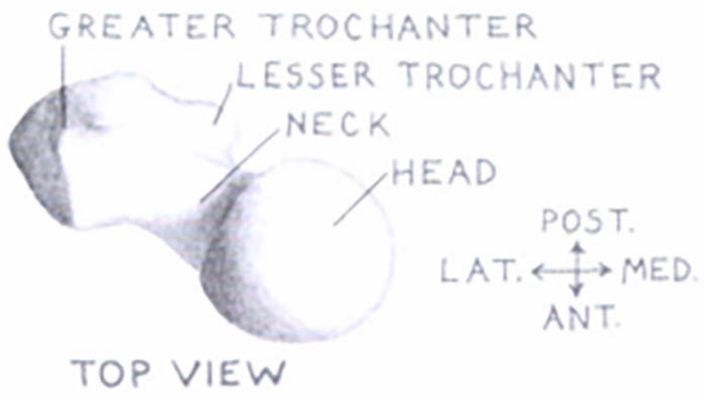
The female pelvis is relatively wider than, and not as high as, the male pelvis; therefore its components are spaced further apart. The ischial tuberosities, the acetabula (and the greater trochanters of the femurs), the front and back points of the pelvis, and the iliac crests are all relatively further apart in the female.

The angle of the female pubic arch is wide and round (similar to the angle between the outstretched thumb and index finger, as contrasted with the narrower angle of the male pubic arch, which is similar to the angle between the outstretched index and middle fingers). The wider female pubic arch places the upper ends of the muscles of the inside of the thighs farther apart than in the male, since the origins of the adductor muscles are situated further away from the midline. This leaves an empty space between the thighs when the legs are together in the female, if the fat here isn't too thick.

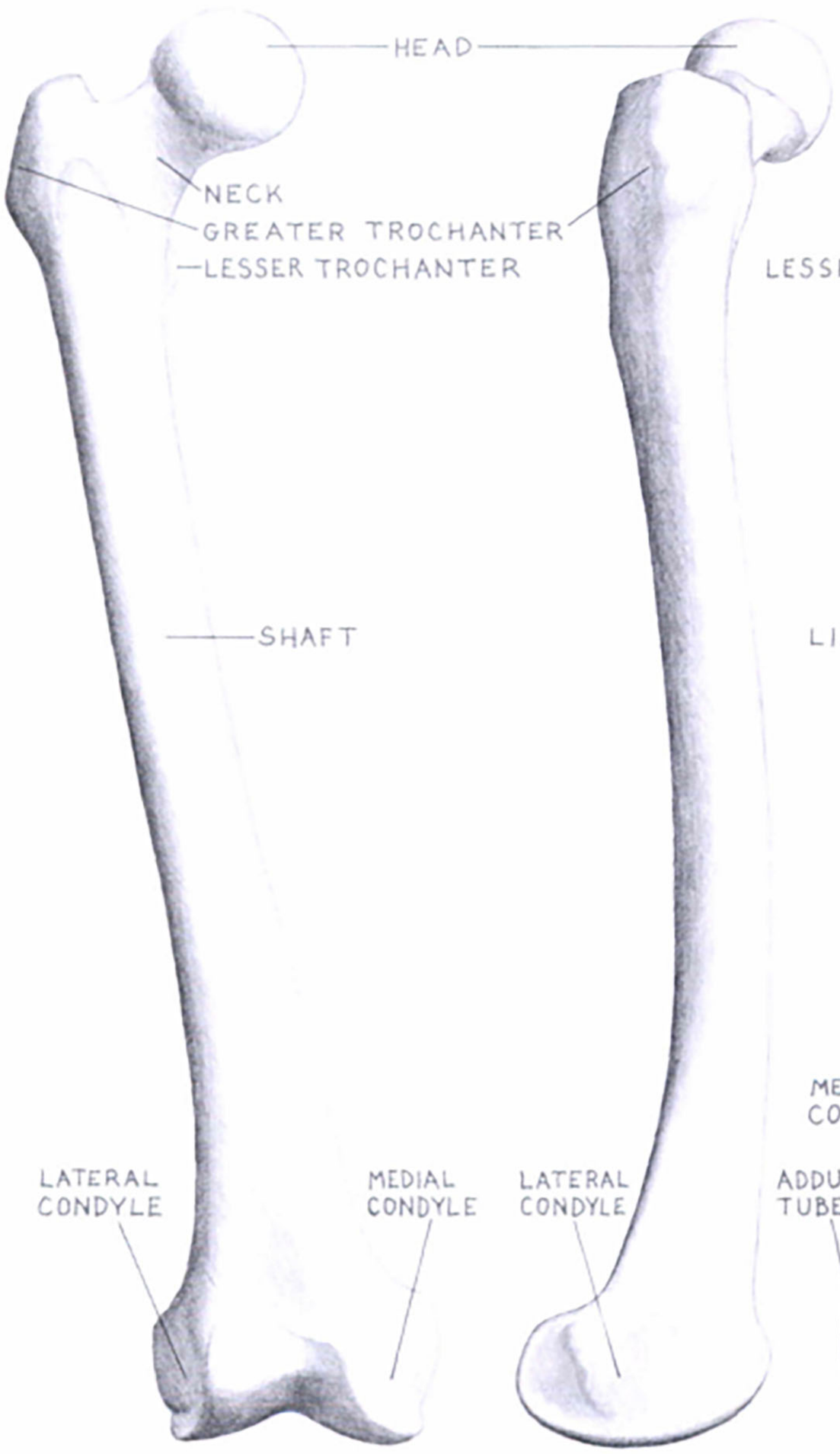
The female sacrum is wider than the male's, and the iliac plates are flatter (face more forward). The greatest width of the iliac crests of the female pelvis is less than the width of the acromions at the shoulder; the male pelvis is even narrower in relation to the shoulders.

The reference position for the orientation of the pelvis is with the front points (ASIS) and the pubic symphysis on the same vertical plane. The pelvis may tip forward or back from this position, the variations being due to individual postural differences rather than differences between males and females.





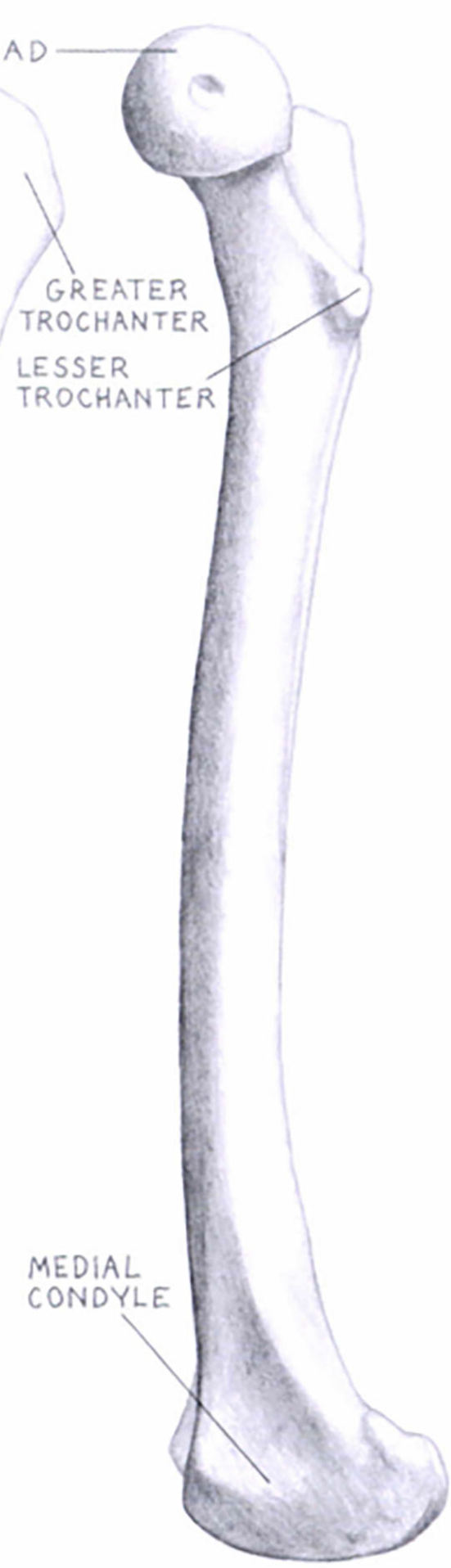
TOP VIEW



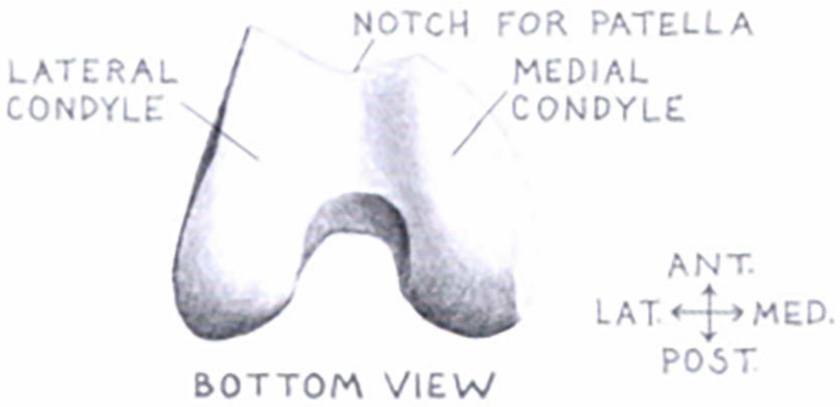
FRONT VIEW
LAT.↔MED.

OUTSIDE VIEW
POST.↔ANT.

BACK VIEW
MED.↔LAT.



INSIDE VIEW
ANT.↔POST.



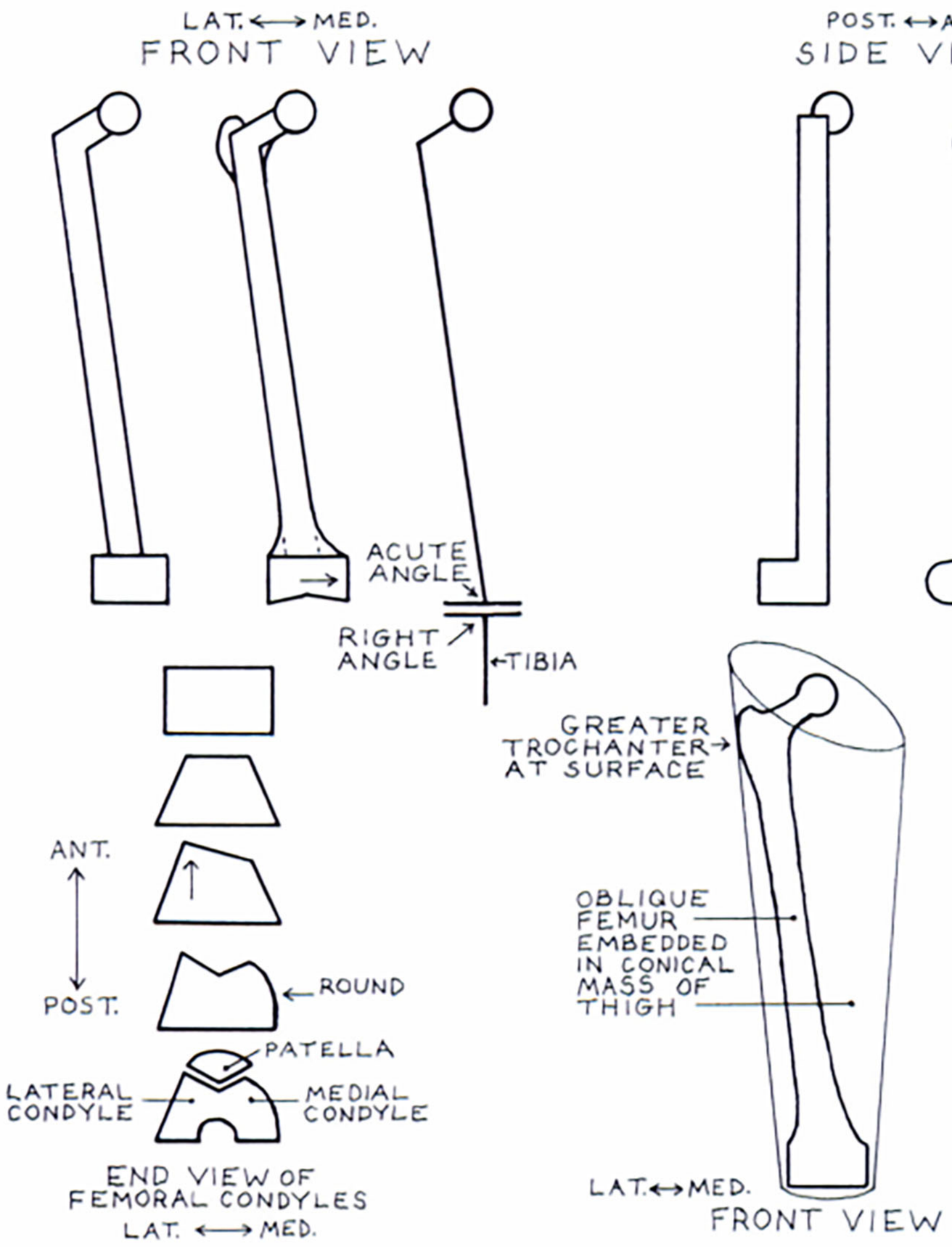
BOTTOM VIEW

The *FEMUR,* or thigh bone, is the longest bone in the body. It is a strong heavy bone that lies obliquely within the muscle mass of the thigh, becoming subcutaneous at the lateral side of the hip and on both sides of the knee. Looking at the front view of the body with the legs together, the superior ends of the femurs are separated by the pelvis, while the inferior ends at the knees touch each other. The femur articulates with the pelvis superiorly and with the tibia inferiorly.

The cylindrical **shaft** has a gentle anterior curvature. Distally, the shaft widens side to side and flattens front to back. The center line on the middle third of the back of the shaft forms a raised ridge, the **linea aspera,** which splits superiorly into three ridges and inferiorly into two, providing concentrated areas for muscle attachment.

Superiorly and laterally, the shaft expands into the bulbous quadrilateral **greater trochanter,** an important subcutaneous bony landmark at the junction of the shaft with the neck of the femur. It is covered with the thin tendons of the gluteus medius and maximus, which do not conceal its form. However, as the thigh is flexed at the hip joint and then laterally rotated, the muscle fibers of the gluteus maximus cover the greater trochanter. In the anatomical position, the greater trochanter is located at the same level as the pubic symphysis—approximately at the midpoint of the figure. In the side view of the skeleton, the greater trochanter is located in front of the midline of the pelvis; however, in life, with the surrounding musculature, it is located more toward the midline of the side view of the body.

The width across the greater trochanters is greater than the width across the iliac crests. The greater trochanters are further apart in the



female than in the male because of the wider female pelvis, which places the femurs in a more oblique orientation (when the knees are touching). When the thigh is abducted at the hip joint, the greater trochanter rises (gets closer to the iliac crest); when it is adducted, the greater trochanter descends, moving away from the crest. In the male, either the greater trochanter or the tensor fascia lata muscle in front of the trochanter is the widest part of the hip. In the female, the fat below the trochanter is widest.

Superiorly and anteriorly, the form of the greater trochanter may blend with the forms of the gluteus medius and the tensor fascia lata muscles, making it difficult to locate on the surface. In life, when the leg is extended, a depression forms behind the greater trochanter. The **lesser trochanter** of the femur lies buried deep in the musculature and does not affect surface form.

From the greater trochanter, the short **neck of the femur** projects medially, upward (forming an obtuse angle to the shaft), and anteriorly (see top view). It functions as a lever for the muscles attaching to the femur. The neck expands into the **head of the femur,** which is approximately three-quarters of a sphere. The head rotates within the deep socket of the acetabulum of the pelvis, at the hip joint.

The distal end of the shaft expands into the large **medial** and **lateral condyles.** They are separated by a deep notch posteriorly, which becomes a shallow depression anteriorly. The posteriorly ridged patella glides in this notch as the knee joint is flexed. The condyles are elongated wheels for rolling and sliding on the top of the tibia. In side view, the condyles project anteriorly only slightly, but there is a considerable projection posteriorly. The femoral condyles together are as wide as the tibial condyles, but are deeper from front to back. Overall, the femoral condyles can be visualized as a somewhat spool-shaped form or as a rectangular box that is narrower anteriorly (the sides converge toward the front). With the patella included, the distal end of the femur is as wide (side to side) as it is deep (front to back). In life, the sartorius passes over the inside of the bony knee, while the short head of the biceps femoris passes over the outside.

In the normal standing position with the knees together (and the tibias parallel), the bottom surface of the femoral condyles is oriented on a horizontal plane that is parallel to the ground. In this position the shaft of the femur is oblique. Its axis intersects with the bottom plane of the condyles at an acute angle; they are not perpendicular.

The **medial condyle** is slightly taller than the lateral condyle, with a more rounded medial surface and a greater projection away from the shaft (see front view). It is partly covered by the vastus medialis, which adds a soft fullness, when the knee is straight or flexed. The medial condyle has an important influence on the surface form of the back of the knee, in the area where it is covered only by the tendons of the semitendinosus and semimembranosus muscles.

The **lateral condyle** is longer front to back than the medial condyle, and its sharp front edge has a more anterior projection (see bottom view). This edge can be seen on the surface in life when the knee is flexed. The outer surface of the lateral condyle is basically flat and planar. It is partially subcutaneous, being covered in part by the iliotibial tract and the end of the short head of the biceps femoris. When the knee is flexed, the outer edges of the bottom surfaces of both condyles become visible just above the tibial condyles on the front of the knee joint, on either side of the patella.

When the knee is flexed, the length of the *lower leg* is visually increased because the thickness of the femoral condyles is added to the top of the tibia.

The *PATELLA,* or kneecap, is the largest sesamoid bone of the body. It is attached to the deep surface of the tendon of insertion of the quadriceps muscle of the thigh. The function of the patella is to move this tendon away from the joint, giving the quadriceps greater mechanical advantage. The deep surface of the patella articulates with the distal extremity of the femur, protecting the articular cartilages of the condyles, especially while kneeling.

The patella is triangular with rounded corners and is flattened from front to back. Its apex is directed inferiorly. The two upper rounded corners are prominent on the surface in life. The anterior surface of the patella is convex, while the posterior surface has a wide vertical ridge which glides in the groove between the condyles of the femur. The inferior apex, attaching to the patellar ligament, is not seen on the surface in the straight extended knee; however, a horizontal skin furrow may appear at this attachment. When the knee is flexed, the anterior surface of the patella forms an angle with the patellar ligament, revealing the apex (in side view). The upper edge of the patella is seen in the flexed knee, not in the extended knee, because the quadriceps tendon meets the patella at an angle during flexion.

In the standing position with the thigh relaxed, the bottom of the patella sits at a level just slightly higher than the line of the knee joint; it rises slightly when the thigh muscles are tensed (with no motion taking place at the knee joint between the femur and tibia). The patella is wider than the distance across the *anterior* portion of the ridges of the medial and lateral condyles of the femur, and therefore covers a portion of these edges when the knee is extended.

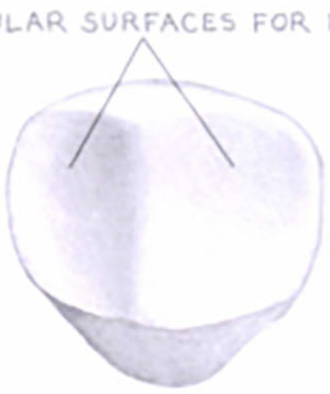
When the knee is straight, the patella sits in the anterior shallow part of the femoral condyle groove. As the knee is flexed, the patella slides down into deeper parts of the groove. This action displaces the patella posteriorly in relation to the anterior profile of the lower leg. When the knee is flexed, the thigh appears longer, because the patella has been dragged around to the distal surface of the condyles of the femur, adding its thickness to the length of the thigh.

RIGHT PATELLA

TOP VIEW

FRONT VIEW
LAT. ↔ MED.

OUTSIDE VIEW
POST. ↔ ANT.

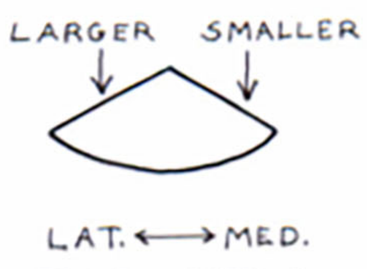


BACK VIEW
MED. ↔ LAT.

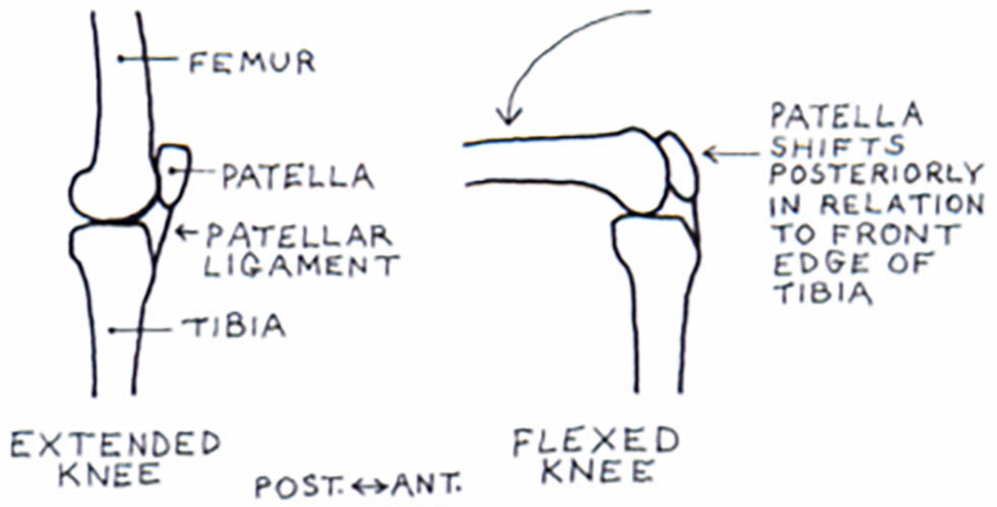
INSIDE VIEW
ANT. ↔ POST.

BOTTOM VIEW

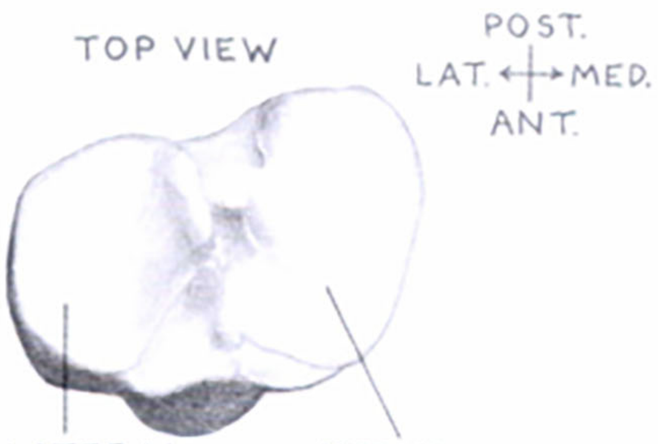
FRONT VIEW

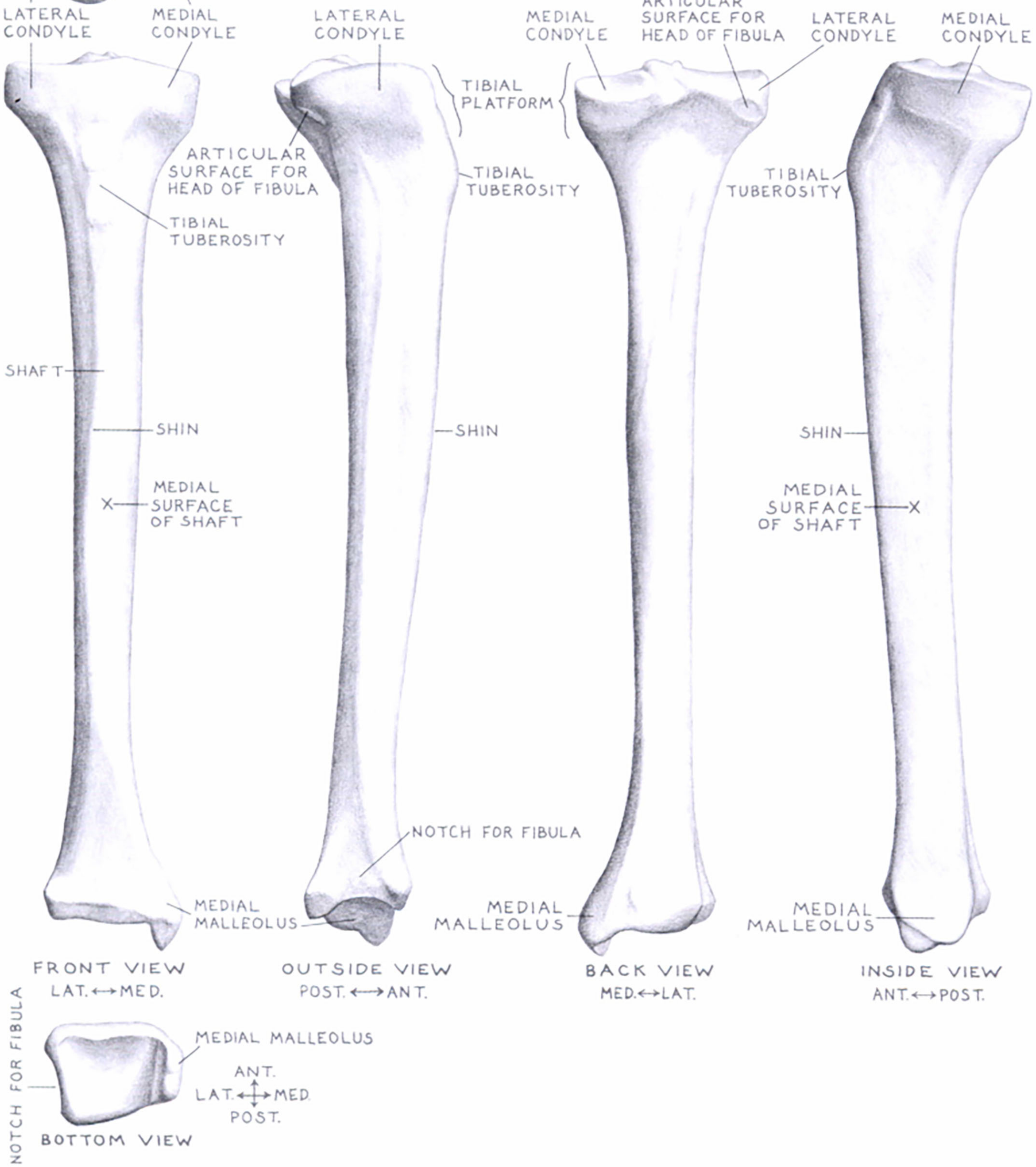


TOP VIEW



SIDE VIEW


TOP VIEW
POST.
LAT. ↔ MED.
ANT.


LATERAL CONDYLE
MEDIAL CONDYLE
ARTICULAR SURFACE FOR HEAD OF FIBULA
TIBIAL TUBEROSITY
SHAFT
SHIN
MEDIAL SURFACE OF SHAFT
X
TIBIAL PLATFORM
NOTCH FOR FIBULA
MEDIAL MALLEOLUS
FRONT VIEW
LAT. ↔ MED.
OUTSIDE VIEW
POST. ↔ ANT.
BACK VIEW
MED. ↔ LAT.
INSIDE VIEW
ANT. ↔ POST.

NOTCH FOR FIBULA
MEDIAL MALLEOLUS
ANT.
LAT. ↔ MED.
POST.
BOTTOM VIEW

The *TIBIA* is the medial and heavier weight-bearing bone of the lower leg. It articulates with the femur superiorly, with the talus bone of the foot inferiorly, and with the parallel fibula laterally at both its superior and inferior ends. It is a long strong bone which transmits the weight of the body to the foot.

The upper three-fourths of the **shaft** is flattened side to side. The shaft is thinnest two-thirds of the way down the bone and deepest front to back at its upper end. It is narrow and triangular in cross section, with the apex directed anteriorly. The **medial surface** of the shaft, an important subcutaneous plane, for the most part faces medially and anteriorly (anteromedially). It is continuous above with the medial condyle and below with the medial malleolus; it is slightly rounded from front to back.

The **tibial tuberosity** (kneeling point) is found at the upper end of the front edge of the shaft, about an inch and a half below the top of the bone. It is vertically elongated, with an upper smooth portion and a lower rough portion. The patellar ligament of the quadriceps muscle glides over the smooth part and inserts into the rough part.

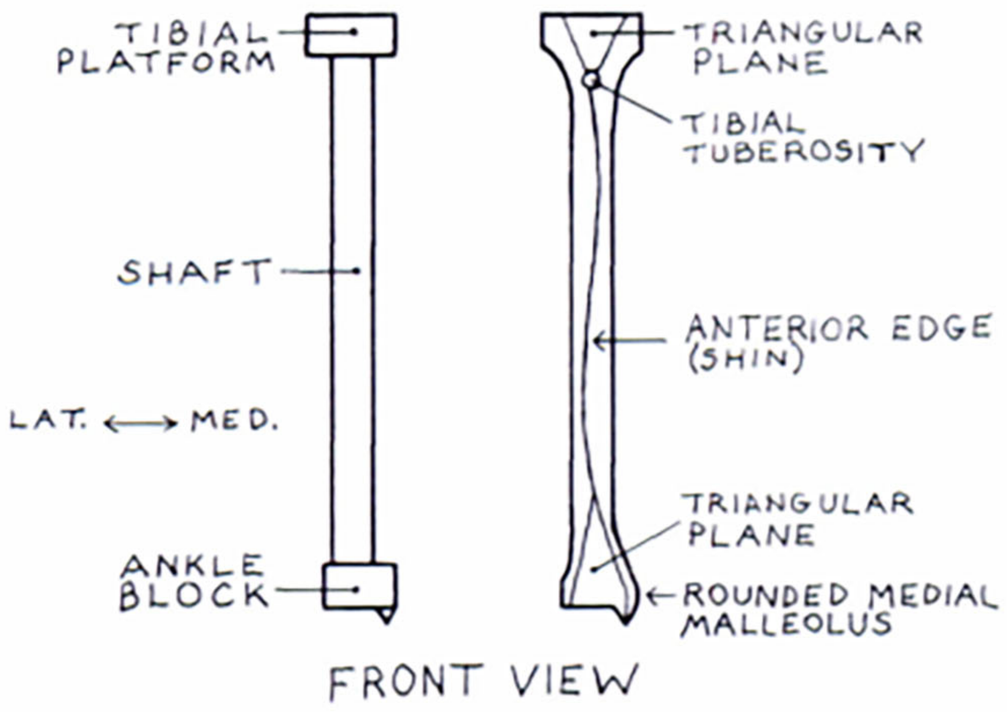
The sharp anterior border of the shaft, or **shin,** begins immediately lateral to the tuberosity and descends in an elongated S curve to a point three-fourths of the way down the bone. In front view, the S first curves medially (making the space for the anterolateral leg muscles) and then laterally.

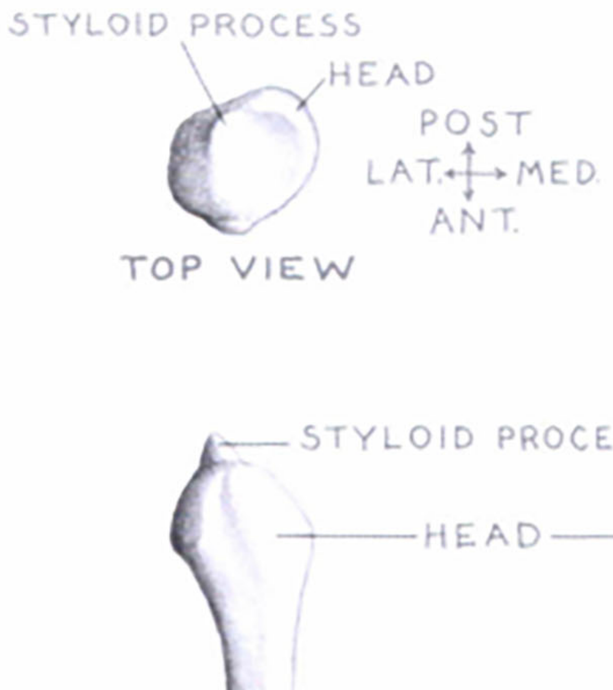
The top of the tibia forms the thick **tibial platform,** wider than it is deep and shaped somewhat like one-half of a disc (it appears like a D in the top view). It is displaced posteriorly on the top of the shaft, causing it to project beyond the top of the shaft in back. The top plane of the platform inclines slightly downward toward the back. It appears horizontal in the front view. The front surface of the platform, just above the tibial tuberosity, forms a plane that is directed forward and upward. The plane is flat and triangular; its apex is directed inferiorly toward the tibial tuberosity. In life, it is covered by the patellar ligament, plus fat when the knee is extended. The tibial platform is about as wide as the condyles of the femur.

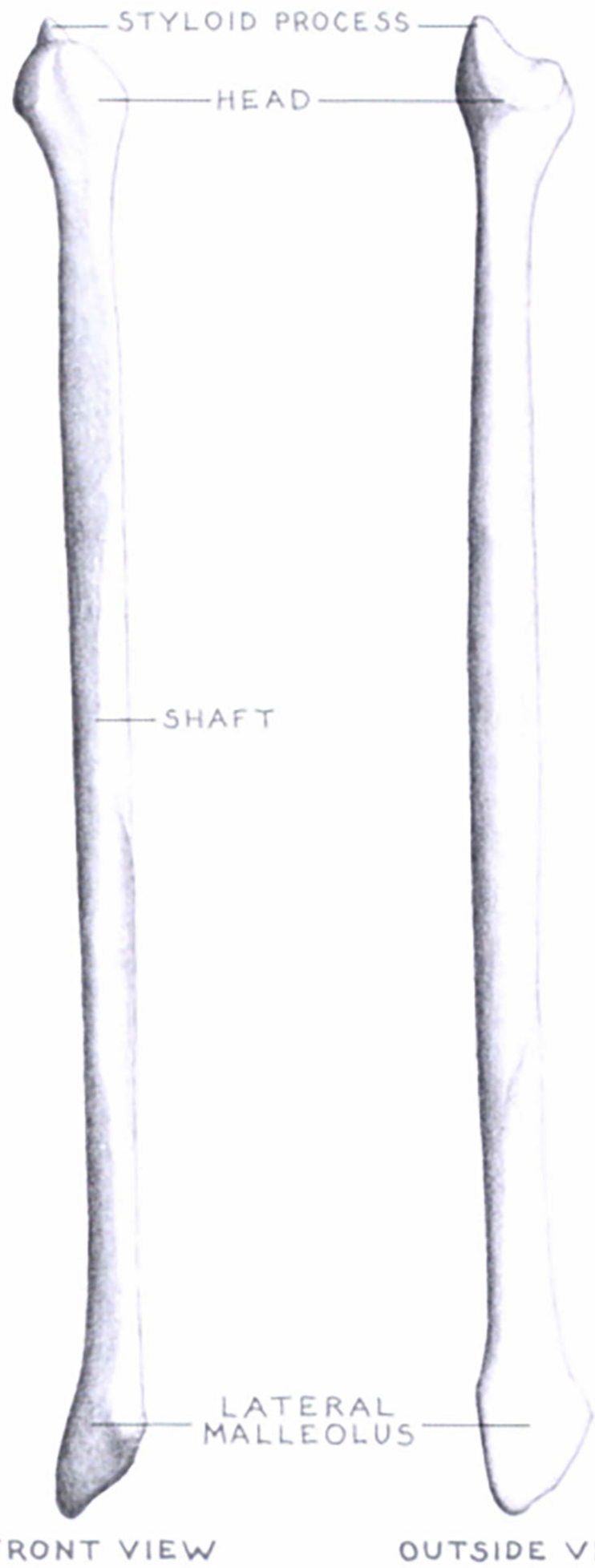
The tibial platform is divided into **medial** and **lateral condyles.** Their top surfaces have elongated shallow facets. These facets articulate with the medial and lateral condyles of the femur. The outer front corner of the lateral condyle is squared-off and prominent in life, especially in the flexed knee. Except for this corner, the medial condyle is the more prominent of the two in life. The form of the lateral condyle blends with the forms of the lower leg muscles below it.

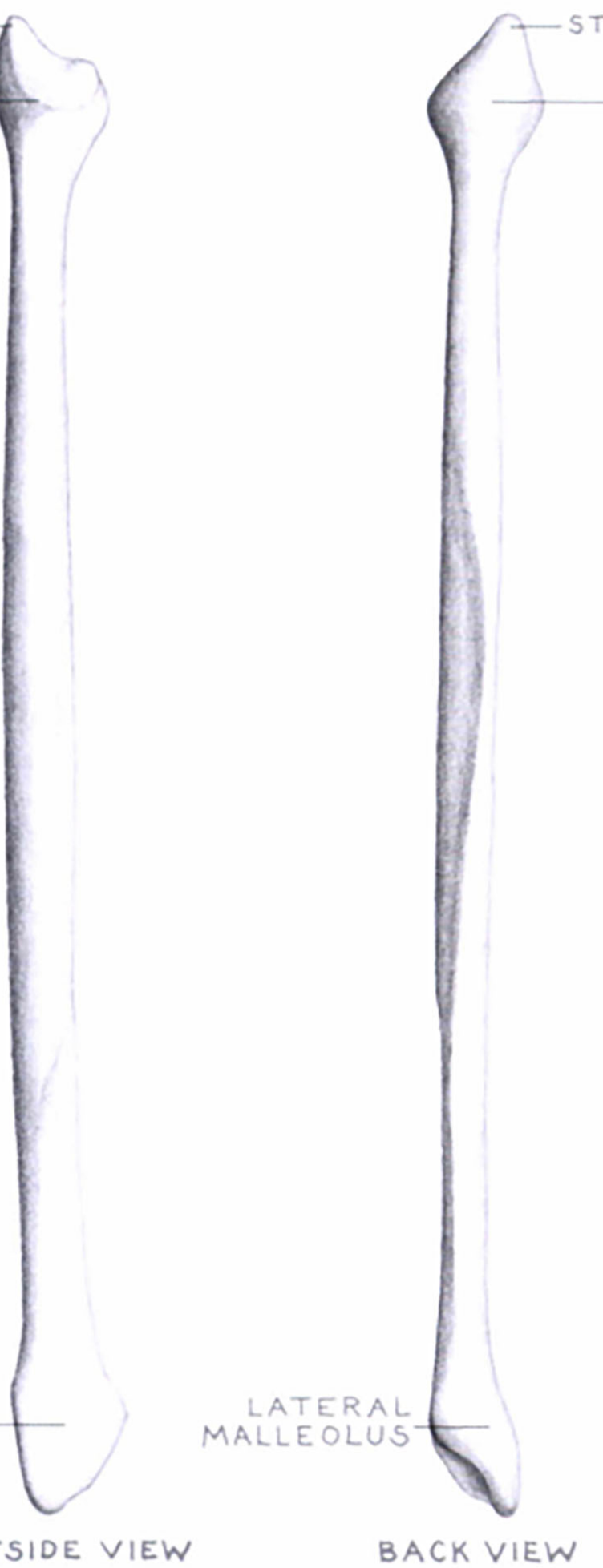
The shaft of the tibia expands inferiorly to blend into the blocklike **distal extremity.** As the shin disappears inferiorly, a flat triangular plane develops on the front of the distal extremity. The lateral surface has a wide shallow notch for reception of the fibula; the medial side forms the projecting **medial malleolus,** or inner ankle bone. The medial malleolus is wider, its lower edge is more rounded, and it is located higher and more anteriorly than the lateral malleolus of the fibula.

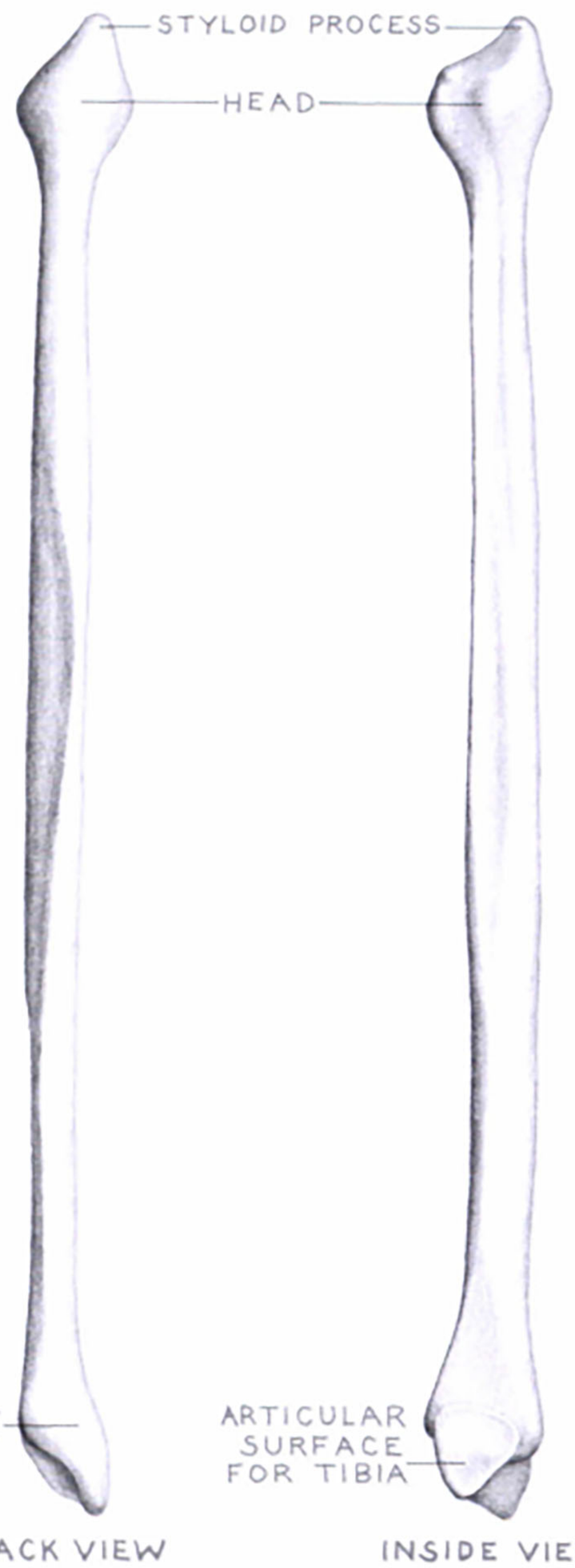
The subcutaneous areas of the tibia are as follows: most of the lateral surface of the lateral condyle, most of the medial surface of the medial condyle, the tibial tuberosity, the entire medial surface of the shaft, and the medial malleolus. The anterior edge of the shaft (shin) is not normally seen on the surface because the fullness of the tibialis anterior muscle lies up against it and bulges forward of its profile. It is, however, easily palpated.




STYLOID PROCESS
HEAD
POST
LAT.
MED.
ANT.
TOP VIEW


STYLOID PROCESS
HEAD
SHAFT
LATERAL MALLEOLUS
FRONT VIEW
LAT.↔MED.


LATERAL MALLEOLUS
OUTSIDE VIEW
POST.↔ANT.


STYLOID PROCESS
HEAD
LATERAL MALLEOLUS
BACK VIEW
MED.↔LAT.

STYLOID PROCESS
HEAD
ARTICULAR SURFACE FOR TIBIA
INSIDE VIEW
ANT.↔POST.

LATERAL MALLEOLUS
ANT.
LAT.
MED.
POST.
BOTTOM VIEW

The *FIBULA* is the thin lateral bone of the lower leg. It articulates with the tibia superiorly and inferiorly, as well as with the talus bone of the foot. Its long, straight, very thin **shaft** (as thin as the little finger) is for the most part deeply buried in muscle. A small portion of the outer surface of the distal end of the shaft becomes subcutaneous before merging into the lateral malleolus. The shaft has different planes and edges on its surfaces which are important for muscle attachments, but they do not influence surface form. It expands into the head superiorly and into the lateral malleolus inferiorly.

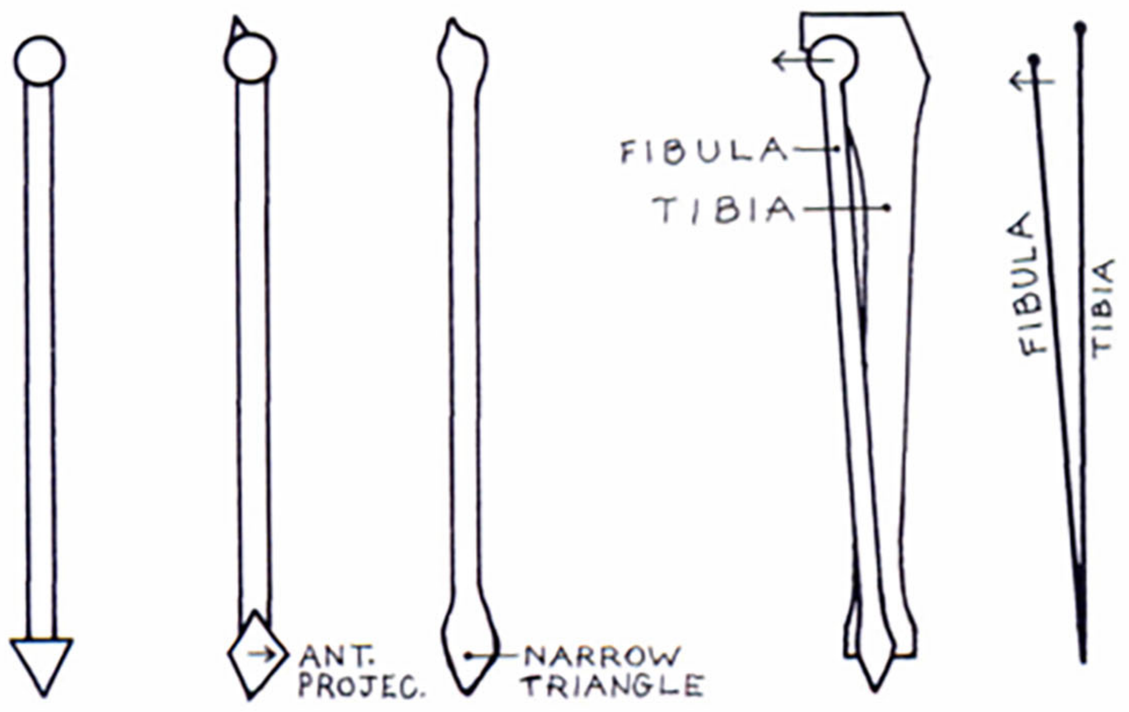
The **head of the fibula,** articulating with the outer back corner of the lateral condyle of the tibia (under a slight overhang), has a somewhat spherical form. It sends up a small upwardly pointed projection, the **styloid process,** from the top of its outer back corner. The styloid process is not visible on the surface. The lateral surface of the head is subcutaneous, but is sometimes difficult to locate on the side of the knee in life because of the bulging of surrounding musculature. The head of the fibula is located a short distance below the levels of the knee joint and the bottom of the patella, and just above the level of the tibial tuberosity on the front of the knee.

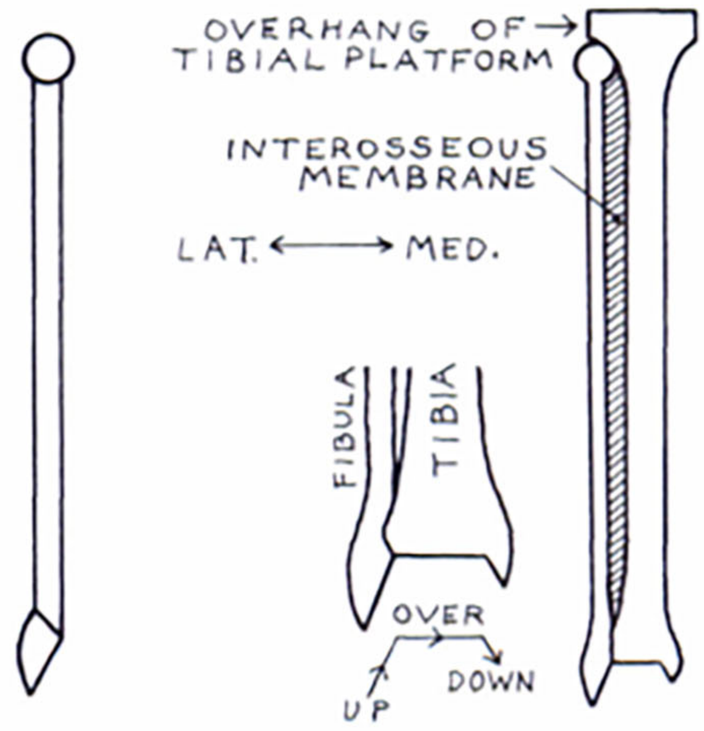
The distal expansion of the fibula, the **lateral malleolus,** which is subcutaneous and quite prominent, forms the outer ankle bone. It is narrower, more pointed inferiorly, and situated lower and slightly more posteriorly than the medial malleolus of the tibia. It is thinner front to back than the distal extremity of the tibia and is lodged in a wide groove in the outer side of the tibia. In side view, the lateral malleolus is diamond-shaped with a slightly greater anterior projection. It is roughly triangular in cross section, showing anterolateral, posterolateral, and deep planes, or it may simply be visualized as convex on its outer surface. The posterolateral surface has a shallow groove for the tendons of the peroneus longus and brevis muscles.

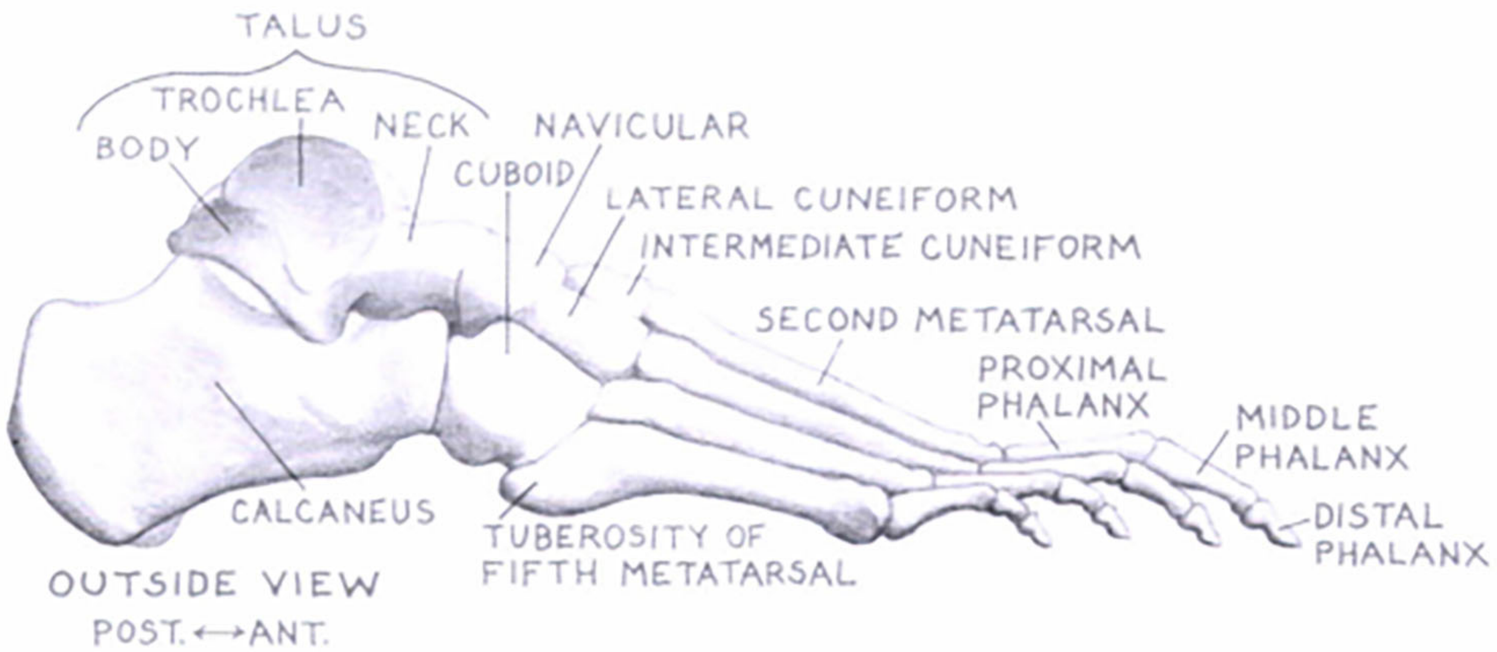
The fibula and the tibia are approximately the same length; however, the fibula is displaced downward slightly in relation to the tibia. This places the top of the head of the fibula below the level of the top of the tibia and the lateral malleolus of the fibula below the level of the medial malleolus of the tibia. The head of the fibula lies below the knee joint and *does not articulate with the femur.*

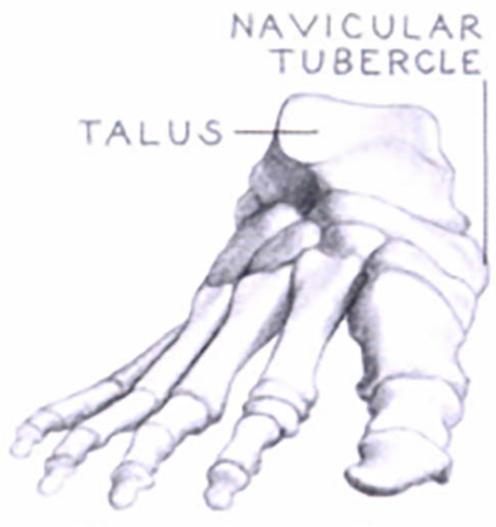
The upper end of the fibula is displaced posteriorly in relation to the top of the tibia, whereas the lower ends of both bones are almost side by side. The long axes of the bones in side view are therefore not parallel, but rather begin at the same point inferiorly and diverge slightly superiorly. In front view, both bones are basically parallel.

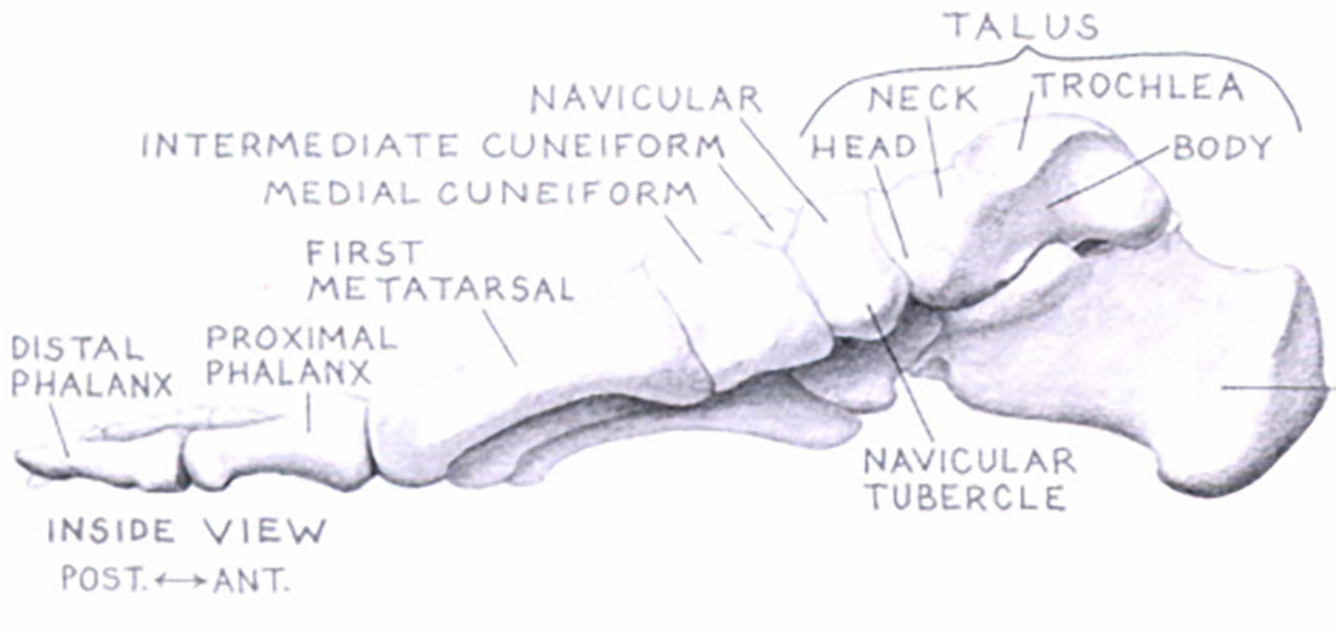
An **interosseous membrane** spans the long narrow interval between the tibia and the fibula. It attaches to the lateral side of the tibia and to the medial side of the fibula. Muscles originate from both the anterior and posterior surfaces of the interosseous membrane.

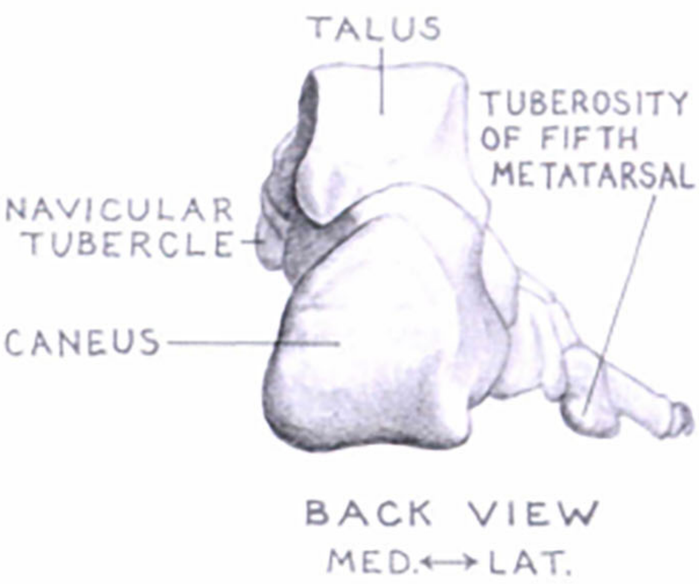


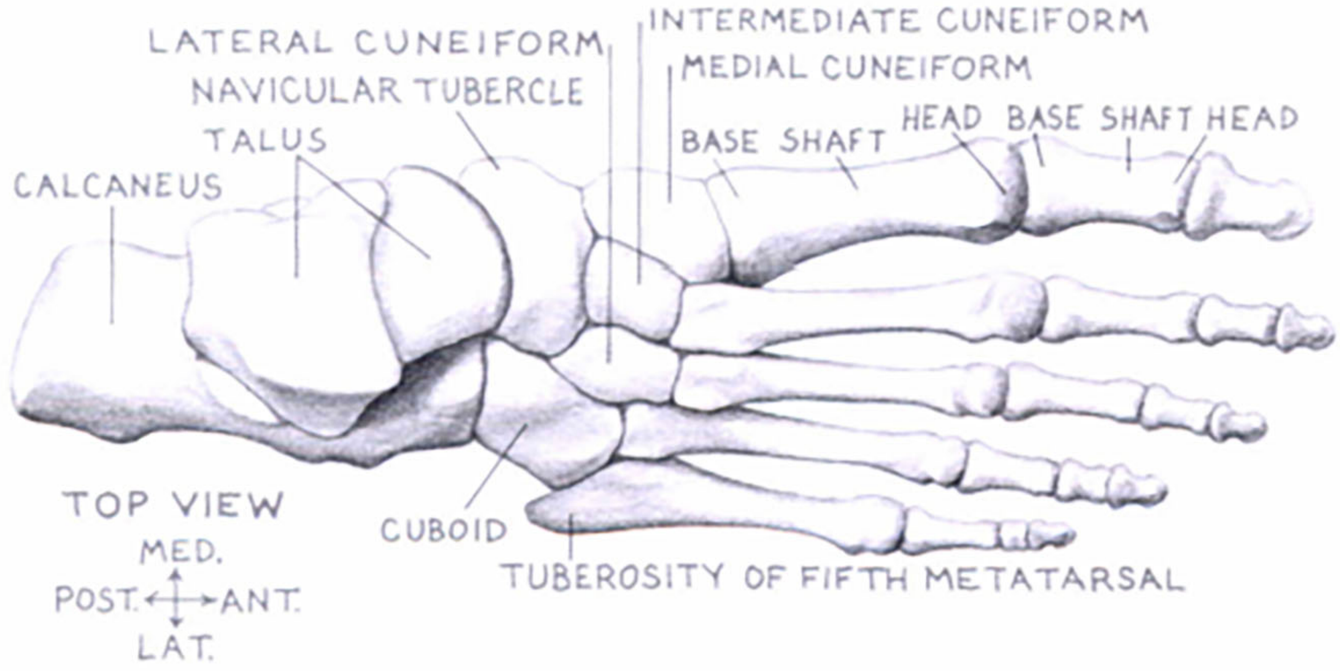


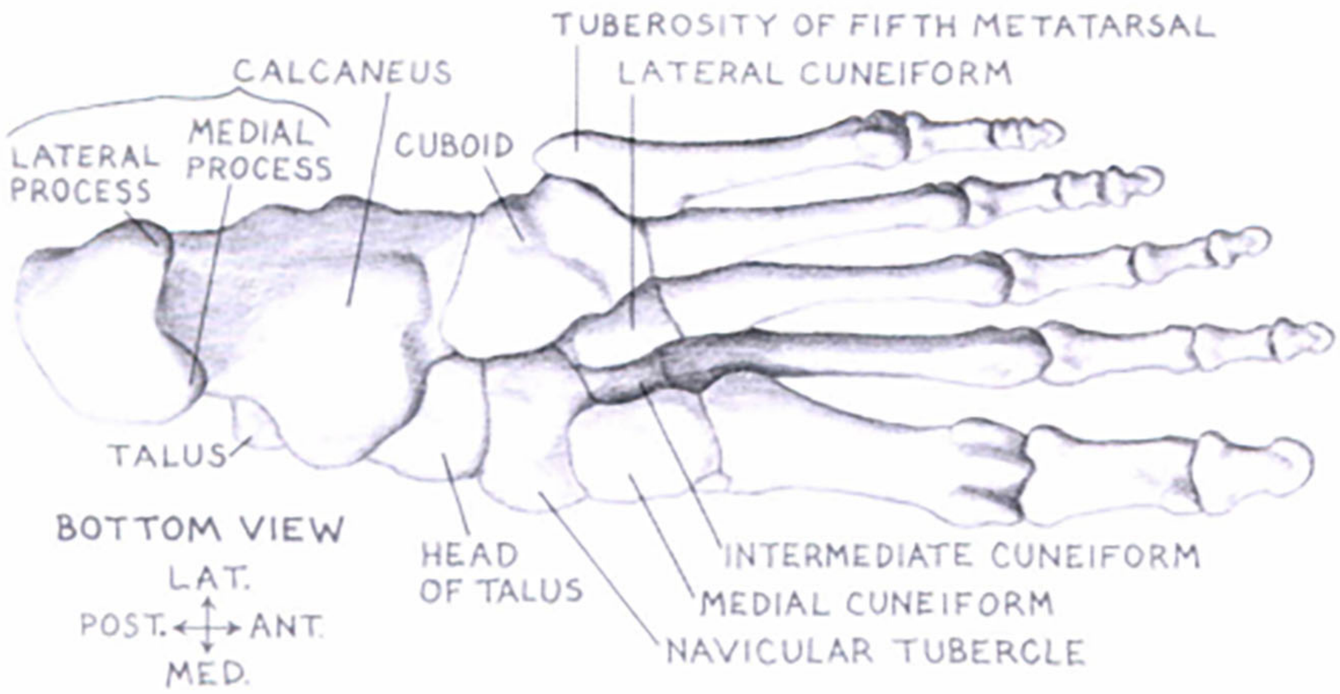

TALUS
TROCHLEA
BODY
NECK
NAVICULAR
CUBOID
LATERAL CUNEIFORM
INTERMEDIATE CUNEIFORM
SECOND METATARSAL
PROXIMAL PHALANX
MIDDLE PHALANX
DISTAL PHALANX
CALCANEUS
TUBEROSITY OF FIFTH METATARSAL
OUTSIDE VIEW
POST. ↔ ANT.


NAVICULAR TUBERCLE
TALUS
FRONT VIEW
LAT. ↔ MED.


TALUS
NAVICULAR
NECK
TROCHLEA
INTERMEDIATE CUNEIFORM
HEAD
BODY
MEDIAL CUNEIFORM
FIRST METATARSAL
DISTAL PHALANX
PROXIMAL PHALANX
NAVICULAR TUBERCLE
INSIDE VIEW
POST. ↔ ANT.


TALUS
TUBEROSITY OF FIFTH METATARSAL
NAVICULAR TUBERCLE
CALCANEUS
BACK VIEW
MED. ↔ LAT.


LATERAL CUNEIFORM
INTERMEDIATE CUNEIFORM
NAVICULAR TUBERCLE
MEDIAL CUNEIFORM
TALUS
BASE SHAFT HEAD BASE SHAFT HEAD
CALCANEUS
TOP VIEW
MED.
POST. ANT.
LAT.
CUBOID
TUBEROSITY OF FIFTH METATARSAL


TUBEROSITY OF FIFTH METATARSAL
CALCANEUS
LATERAL CUNEIFORM
LATERAL PROCESS
MEDIAL PROCESS
CUBOID
TALUS
BOTTOM VIEW
LAT.
POST. ANT.
MED.
HEAD OF TALUS
INTERMEDIATE CUNEIFORM
MEDIAL CUNEIFORM
NAVICULAR TUBERCLE

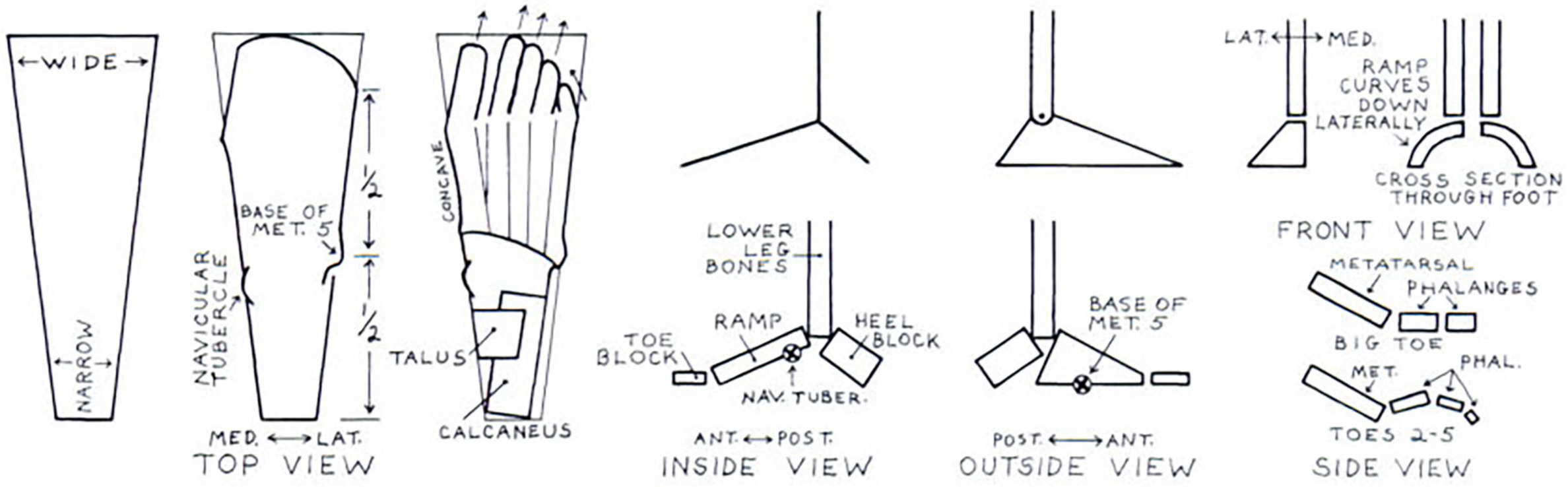
The *SKELETON OF THE FOOT* is designed to provide stability in supporting and distributing the body's weight and resiliency when receiving the impact of the body's weight while walking, running, and jumping. It also acts as a lever, pushing the body forward during locomotion. It is rigid upon takeoff and flexible upon impact. The foot skeleton is composed of the tarsus, metatarsus, and phalanges, and except for the phalanges of the lateral four toes, its bones are characterized by their thickness and strength. The phalanges are shorter than the metatarsals, which in turn are shorter than the tarsals. This arrangement is opposite to that found in the hand, where the carpus is short and the phalanges are long. In the foot, the big toe is restricted to lying parallel to the other toes, unlike the thumb, which is capable of opposing the other fingers.

The foot has two perpendicular arches: a longitudinal arch from front to back and a transverse arch from side to side. These arches not only distribute weight but also afford the foot a degree of elasticity, providing shock absorption. The **longitudinal arch** is actually a series of five almost parallel (slightly radiating) arches passing through the long axes of the five toes. There is a high medial arch on the inside of the foot and a very low lateral arch on the outside (the base of the metatarsal of the little toe does not support weight in the foot flat on the floor). The **transverse arch** curves across the foot, bringing the outer edge of the foot down toward the ground. It is most noticeable at the midpoint of the foot, where it is high on the inside and low on the outside. The muscles, tendons, ligaments, and fasciae of the foot maintain these arches.

The *TARSUS* contains seven stout tarsal bones: the talus, calcaneus, cuboid, navicular, and three cuneiforms. There is substantial movement within the tarsus.

The **talus** (astragalus), located above the calcaneus near the back end of the medial side of the foot, consists of a **body,** an anteriorly projecting **neck,** and a rounded **head** in front. The upper articular portion of the body, the **trochlea,** is spool-shaped. It is the highest bone of the foot and articulates superiorly with the tibia and fibula to form the ankle joint. Only flexion and extension are possible at this joint. The talus articulates inferiorly with the calcaneus at the **subtalar joint** and anteriorly with the navicular. The subtalar joint permits inversion and eversion of the foot. The lateral edge of the trochlea of the talus becomes visible on the surface in front of the lateral malleolus of the fibula during extreme plantar flexion of the foot (toe pointing). During inversion of the foot (facing the foot inward), the lateral part of the head of the talus shows under the tendons of the extensor digitorum longus, while the medial part of the head shows during eversion (facing the foot outward) between the medial malleolus and the navicular tubercle. These points of the talus, when seen, appear as subtle prominences.

The **calcaneus,** or heel bone, is blocklike, flattened side to side, and rounded on its posterior surface. It is the largest foot bone. It is inclined upward, forward, and slightly laterally, resting its lower back edge on the ground (protected below by the fatty cushion of the sole of the foot). The calcaneus acts as a lever. Most of the lateral surface and part of the posterior surface (between the insertion of the Achilles tendon and the heel cushion) are subcutaneous. The Achilles tendon conceals the upper part of its back surface.



The **navicular bone** is located between the talus and the medial cuneiform. Its medial end, the **navicular tubercle,** is usually prominently seen on the inside of the foot a short distance below and anterior to the medial malleolus of the tibia, especially when the foot is inverted. The tendon of the tibialis posterior can be seen attaching to the inferior surface of this tubercle.

The **cuboid** and the three **cuneiforms** are not differentiated on the surface. They form the distal row of the tarsus and are tightly bound together by ligaments. Their upper surfaces contribute to the formation of the top surface, or **dorsum,** of the foot.

There are five *METATARSAL* bones, located between the tarsus and the phalanges. (Remember T for Toes to differentiate metaTarsal from metaCarpal). Each metatarsal consists of a proximal **base,** a distal **head,** and a **shaft,** or body, in between. The shafts are slightly convex dorsally. The heads are noticeable as rounded prominences on the dorsal surface of the foot in life when the toes are flexed. The medial surface of the first metatarsal and the upper surface of the fifth metatarsal are subcutaneous.

The metatarsal of the big toe, or **hallux,** is the shortest and thickest. The medial surface of its shaft is seen on the surface as a concave curve on the inner side of the foot. There are two **sesamoid bones** located on the plantar surface under its head, near the metatarsophalangeal joint. The metatarsophalangeal joint itself appears rounded and enlarged on the surface. The articulation of the base of the first metatarsal with the medial cuneiform is the midpoint of the skeleton of the foot from front to back and is noticeable on the dorsum of the foot by the subtle angle where these two bones meet. The other four metatarsals are long and slender and are approximately all the same length. The highest of the bases of the metatarsals on the dorsum is that of the second toe. The shaft and base of the fifth metatarsal are raised slightly off the ground. The base does not support weight and is slightly raised to form the lateral longitudinal arch. The lateral aspect expands into a **tuberosity** which forms an important bony landmark on the outer edge of the foot. Its prominence is located approximately midway between the back of the heel and the *tip of the little toe.*

The toes are made up of the *PHALANGES* (singular: **phalanx**). They articulate with the metatarsals at the **metatarsophalangeal joints.** The joints between the phalanges are the **interphalangeal joints.** A phalanx consists of a proximal **base,** a **shaft,** and a distal **head.** The big toe has only two phalanges, proximal and distal, while each of the other toes has three—proximal, middle, and distal. The phalanges of an individual toe become shorter distally. The phalanges of the big toe are necessarily heavier and stronger for pushing off during forward locomotion (walking, running, and jumping), as well as for supporting the body's weight when standing on tiptoe. The phalanges of the lateral four toes are very thin and delicate. The tip of the distal phalanx of each toe is flattened from above to below. The toenail attaches to the top of this flattened surface by an intervening fatty cushion. The middle and distal phalanges of the little toe are often fused together. The heads of all five proximal phalanges and the heads of the middle phalanges of the lateral four toes are squared-off, which is noticeable on the surface in life when the toes are flexed. The squared-off heads of the phalanges contrast with the rounded heads of the metatarsals.

In the normal standing position, the phalanges of the middle three toes arch upward and then point down, their padded tips resting on the ground (side view). This means that both their proximal and distal interphalangeal joints are slightly flexed. The distal interphalangeal joint may at times be straight or even slightly extended, but classically it is flexed slightly. The three phalanges of a toe can therefore be thought of as arching "up, over, and down," giving a dynamic sense to the structure of the middle three toes. The arch of the little toe is rounded into a single curve in life and classically arches the highest. In side view, the two phalanges of the big toe are straight in line and are horizontal or point slightly upward distally.

The axis of the phalanges of the big toe is directed laterally from the metatarsophalangeal joint. There is a gap between the phalanges of the big toe and the second toe. The second and third toes are parallel to the big toe (their axes are directed back toward the medial malleolus). The axis of the fourth toe is usually parallel to the first three toes. The little toe is directed medially. Either the big toe or the second toe may be the longest, or they may be equal in length. Classically, the second toe is longer.

In the standing position, the weight of the body rests on the lower back edge of the calcaneus and on the heads of all five metatarsals, especially that of the big toe. The phalanges passively rest on the ground. The foot spreads out when weight is placed on it, getting wider and longer because of the reduction of the heights of the longitudinal and transverse arches. The width across the middle of the foot, from the medial cuneiform to the base of the metatarsal of the little toe, is approximately one-third of its length. The foot is widest anterior to the midpoint, across the metatarsal heads.

The *JOINTS,* or **articulations,** are located at the ends or edges of bones, in the areas where they touch each other and usually move against one another. **Arthrology** is the study of joints. The key to understanding the movement of the body is through knowledge of the design and range of motion of the individual joints and of the ligaments that restrict or control those movements. At a joint, motion occurs around one or more axes.

Types of Joints

Joints are classified as fibrous (basically immovable), cartilaginous (slightly movable), or synovial (freely movable).

FIBROUS JOINTS have very little or no movement. This type of joint has a thin layer of fibrous connective tissue located between the adjoining edges of bones, fastening them together. Fibrous joints in the skull, connecting the cranial and facial bones, are called **sutures.** They may be zig-zagged and interlocking or flat and either abutting or overlapping. The distal tibiofibular joint is an example of a fibrous joint that has a minimal amount of motion.

CARTILAGINOUS JOINTS have fibrocartilaginous discs located between articulating bony surfaces. Because of the thickness and resiliency of a disc, slight motion is possible. Examples of this type of joint are the pubic symphysis, the sternal angle between the manubrium and the body of the sternum, and the joints between the vertebral bodies. Although motion is slight between each vertebra, combined motion along all the vertebrae is quite extensive. Cartilaginous joints are located on the median plane of the body.

The motion at *SYNOVIAL JOINTS* ranges from extensive (at the shoulder joint) to slight (between some of the carpal bones of the hand). At these joints, the ends of bones move against one another, and their articulating surfaces are covered with smooth **articular cartilage** (which usually does not show up in X-rays). Lubricating **synovial fluid** is secreted within the capsules that surround these joints. At synovial joints, the positions of the ends of the bones in relationship to one another are maintained by the surrounding ligaments and muscles. Ligaments usually restrict motion, permitting only the desired motion to take place. Joint motion is limited in the following ways: by tension developed in the surrounding ligaments and muscles when they become fully stretched and taut (extension of the knee and hip joints); by one bone coming in contact with another bone deep in the joint (extension of the elbow joint; dorsiflexion of the ankle joint); or when two muscle masses come in contact with each other (flexion of the knee when the calf hits the hamstrings on the back of the thigh). When muscles surrounding a joint contract simultaneously, motion of that joint can be frozen at any point in its range of motion.

Flat cartilaginous structures are sometimes located between two articulating surfaces within a joint. Examples of these are the **menisci** in the knee joint and the **articular discs** in the sternoclavicular joint and the temporomandibular joint of the jaw.

The following synovial joints are classified according to their structure or function:

Hinge joint (ginglymus joint). Hinge joints can only swing back and forth, restricting bone movement to one plane. Examples are the elbow joint between the humerus and ulna and the interphalangeal joints of the fingers and toes. The type of motion at hinge joints is limited to flexion and extension.

Pivot joint (trochoid joint). In a pivot joint a bone rotates around its long axis. At the joint itself, the rounded end of one bone rotates *within* a ligamentous ring and bony notch of another bone, or a notched bone rotates *around* another bone's rounded end. Both the proximal and distal articulations of the radius with the ulna, as well as the joint between the atlas and axis of the neck vertebrae, are pivot joints.

Ball-and-socket joint (spheroid joint). This type of joint is the most movable and permits motion in all directions (flexion/extension, abduction/adduction, rotation, and circumduction). The rounded head of one bone fits into the cupped socket of the other. The shoulder joint is a shallow ball-and-socket joint, and the hip joint is a deep one. The deeper the socket, the greater the stability; however, the range of motion is reduced.

Condylar joint. A condylar joint is a very shallow ball-and-socket joint that allows flexion, extension, abduction, adduction, and circumduction. Its ligaments prevent rotation. The metacarpophalangeal joints of fingers two through five are condylar joints.

Ellipsoid joint. At this modified ball-and-socket joint, an oval convexity of one articular surface sits in an oval concavity of another. These joints allow motion on opposite planes—flexion and extension on one, abduction and adduction on the other. Rotation is prevented by the ellipsoid shape of the articulating surfaces; however, circumduction is permitted. The radiocarpal joint of the wrist is an ellipsoid joint. An ellipsoid joint can be considered an oval condylar joint.

Saddle joint (sellar joint). At a saddle joint, the articular surface of each articulating bone has a double curvature—convex in one direction and concave in the other. Convex curva-

tures sit opposite concave ones. Their corresponding surfaces are reciprocally congruous. The carpometacarpal joint of the thumb, a saddle joint, permits flexion, extension, abduction, adduction, and circumduction, but only slight rotation.

Plane joint (gliding joint). A plane joint permits slight or moderate sliding or rotation of one bone against another. The articulating surfaces may be flat or slightly concave/convex. These joints are found in the carpus and tarsus.

Types of Movements

Flexion decreases the angle between two bones, bringing two body parts closer together. *Bending* the elbow, lifting the thigh to the chest, raising the arm in front of the body, and clenching the fingers into a fist are examples of flexion. **Extension** widens the angle between bones, *straightening* the joint and moving the body parts away from each other. Straightening the elbow and the knee, moving the arm posteriorly, and arching the back are examples of extension. **Hyperextension** occurs when the body parts are extended past a straight line or past the normal anatomical position; it is seen regularly in the metacarpophalangeal joints of the hand and the metatarsophalangeal joints of the foot and occasionally in the elbow and knee. Flexion and extension are opposite movements, and the muscles producing these movements are called flexors and extensors, respectively. Special terminology is used for the foot. Approximating the dorsal surface of the foot with the front of the lower leg (lifting the foot) is referred to as **dorsiflexion.** Pointing the foot is called **plantar flexion.**

Abduction (*abd*ucted = taken away) is moving a limb *away* from the centerline of the body or moving a finger or toe away from the centerline of the hand (middle finger) or foot (second toe). Spreading the fingers or raising the arm or leg directly outward, away from the side of the body, are examples of abduction. **Adduction** (*add*ed = brought together) brings a limb or finger back toward, or beyond, the midline. Adduction of the limbs is often brought about by gravity alone. Abduction and adduction are opposite actions, and the muscles producing these actions are called abductors and adductors, respectively.

Circumduction can be thought of as a combination of movements in sequence: flexion, abduction, extension, and then adduction (or vice versa). The proximal end of a bone pivots, while its distal end traces the circumference of a circle; in other words, the entire circumducting part describes the surface of a cone. Circumduction takes place at the hip, shoulder, wrist, and metacarpophalangeal joints. The head and neck as a unit, as well as the thorax, can be circumducted at the cervical and lumbar vertebrae, respectively.

Rotation takes place when a bone rotates around its long axis. Bones articulating at ball-and-socket joints, such as the humerus at the shoulder joint, as well as those at pivot joints, for example, between the radius and ulna (permitting pronation and supination), can be rotated. Rotation also occurs between the atlas and axis in the neck. A bone or body part is described as being rotated medially or laterally around its longitudinal axis, or in the case of the head and thorax, to the left or to the right.

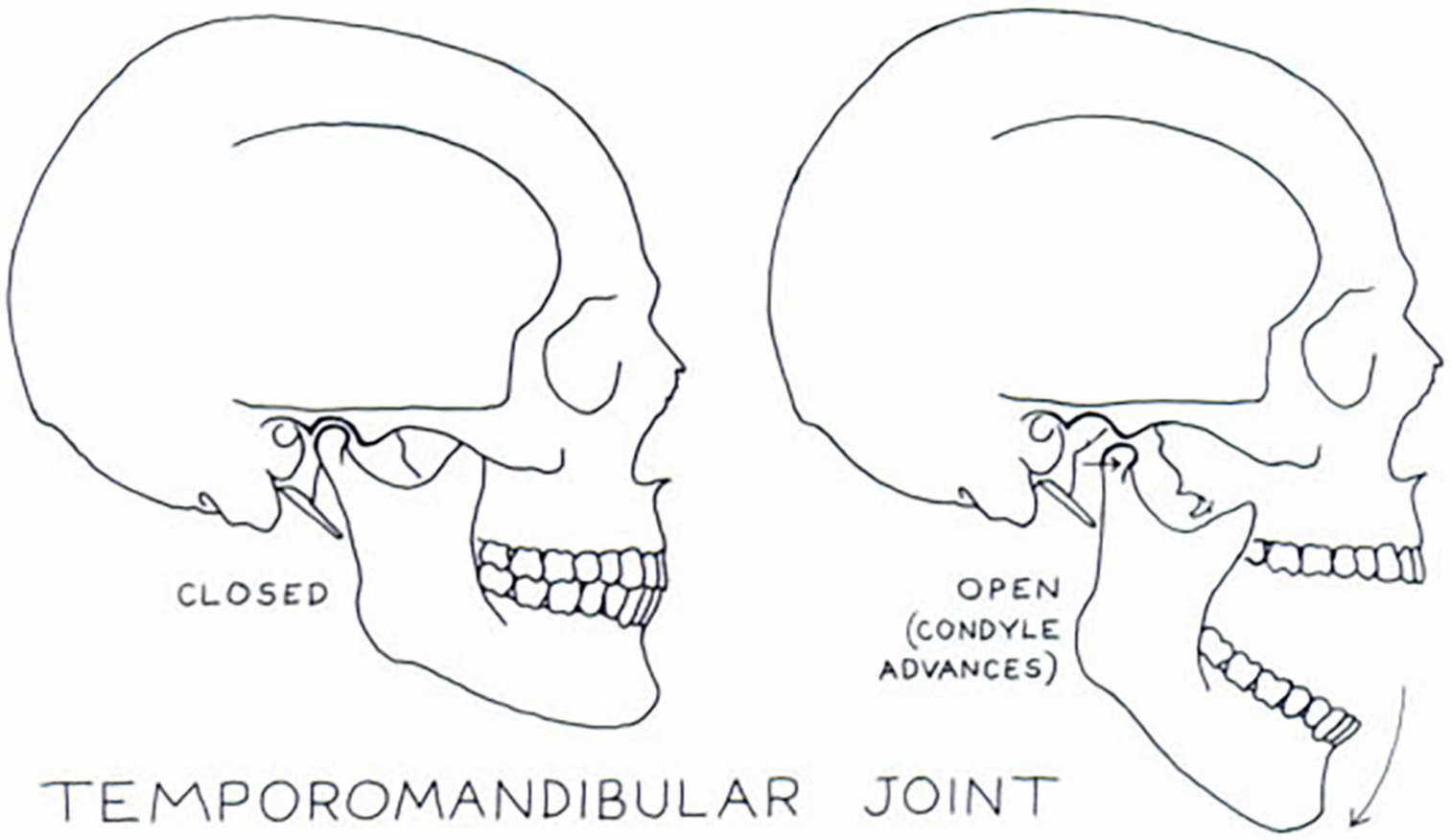
Gliding, as its name implies, occurs when two articular surfaces slide against one another. Plane joints are basically limited to gliding. Gliding can also take place in joints that have other types of movement, for example, the knee joint during flexion, where the femoral condyles on top of the tibia glide forward as they simultaneously roll backward (the forward gliding prevents the condyles from rolling backward off the top of the tibia).

Joints—Axial Skeleton

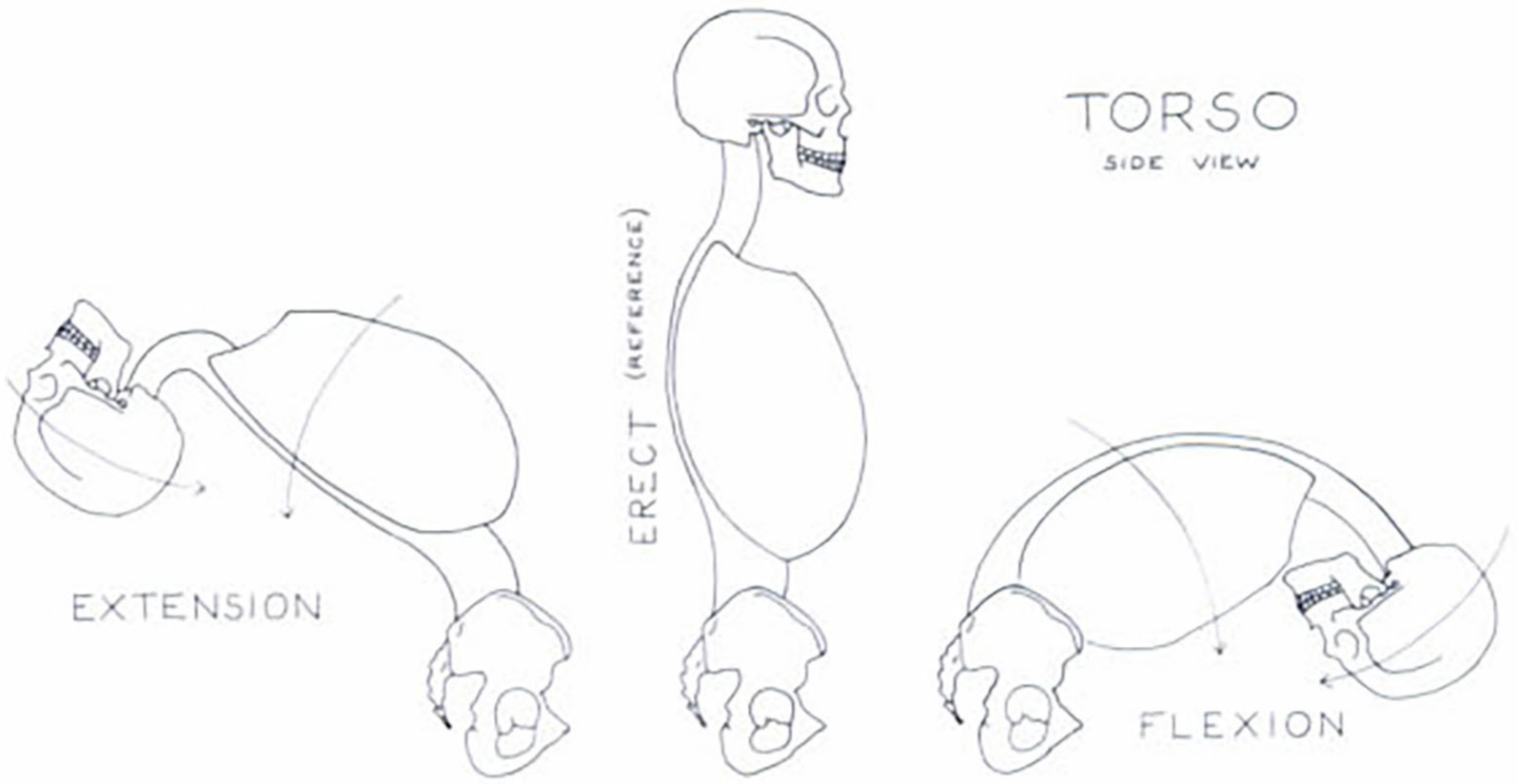
The **axial skeleton** consists of the skull, vertebral column, ribs, and sternum.

The only movable joint of the *SKULL* is the **temporomandibular joint,** which is the articulation of the lower jaw, or mandible, with the temporal bone of the cranium. It is a *condyloid joint* that contains a fibrous articular disc located between two bony articular surfaces. The lower jaw opens and closes (raises and lowers), moves side to side (to grind food), and shifts forward and back (protrudes and retracts). When the mouth is opened, not only does the mandible pivot at this joint, but its condyles also slide forward and downward, out of its notched socket and onto the bony tubercle on the bottom of the zygomatic arch (the condyle slides on the disc; the disc slides on the tubercle). The subcutaneous lateral ends of the mandibular condyles can easily be felt and at times can be seen moving in front of the ear hole as the mouth is opened and closed. In the resting position, the jaw (not the lips) is held slightly open. When the jaw is fully opened, three finger widths can be placed between the front teeth.

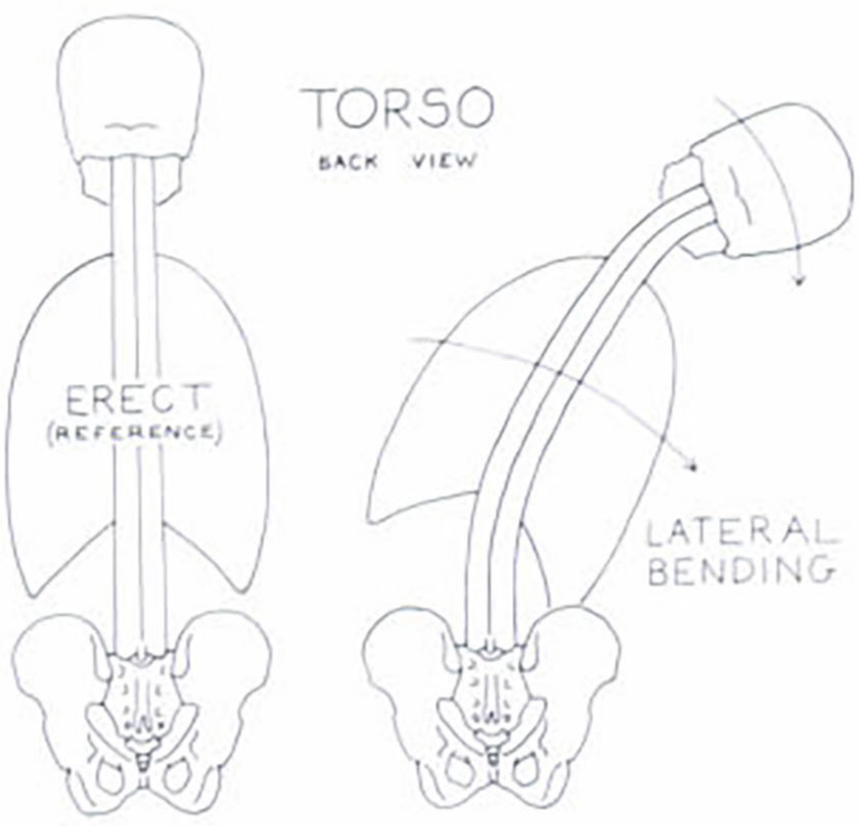
The *VERTEBRAL COLUMN* is a stacked column consisting of twenty-four movable vertebrae (seven cervical, twelve thoracic, and five lumbar), each separated by a fibrocartilaginous intervertebral disc (except between the first two cervical vertebrae), plus the sacrum and coccyx.



TEMPOROMANDIBULAR JOINT



TORSO
SIDE VIEW



TORSO
BACK VIEW

The discs create "swiveling" or "rocking" *cartilaginous joints* between the bodies of the vertebrae; they also function as shock absorbers.

The entire column can flex, extend, bend laterally, rotate along its long axis, and circumduct; however, the degree of these different motions varies among the regions of the spine. There is only slight movement between the individual vertebrae, yet considerable movement in the vertebral column as a whole. The anterior portion of the vertebral column, made up of the vertebral bodies, provides support, while the posterior portion, containing the articular processes, guides and limits the movements.

The first cervical vertebra, or atlas, articulates superiorly with the two occipital condyles of the skull at the **atlanto-occipital joints.** These are *ellipsoid joints* that permit primarily flexion and extension of the head, enabling the head to tip forward and back without involving the other cervical vertebrae. Approximately fifty percent of cervical flexion and extension takes place at these joints. A slight degree of lateral tilting of the head also occurs here. At the **atlantoaxial joint** between the first and second cervical vertebrae, the atlas rotates on top of the axis. The atlas pivots around the upward-projecting dens of the axis *(pivot joint)*, allowing the head to turn side to side, also without involving the other cervical vertebrae. Approximately fifty percent of cervical rotation takes place at this joint. The remaining cervical vertebrae permit extensive flexion, extension, lateral bending, rotation, and circumduction. The neck can be extended more than it can be flexed. Flexion stops when the chin touches the chest. The cervical region is the most flexible portion of the spine.

The **thoracic vertebrae** permit substantial rotation and only slight flexion, extension, and lateral bending. Motion is partly limited in the region of the middle thoracic vertebrae.

The **lumbar region** is capable of much extension, slightly less flexion, a considerable amount of side bending, but very little rotation because of the design of the lumbar articular facets. There is more movement in the upper portion than in the lower portion, because the two lowest lumbar vertebrae are connected to the sacrum by strong ligaments. Extension is restricted at the point where the spinous processes in back touch each other. Extension increases the forward curvature of the lumbar region. Most spinal extension in the torso takes place in this region.

The **sacrum** is rigidly locked between the two hip bones. There is no motion between the sacrum and the **coccyx,** nor is there any motion within the coccyx itself.

The first ten *RIBS* articulate at their heads with the vertebral bodies and at their tubercles with the transverse processes of the vertebrae. The eleventh and twelfth ribs articulate only at their heads with the vertebral bodies. These articulations are all *plane joints,* which permit rotation of the individual ribs, cumulatively resulting in elevation of the rib cage. During inhalation, the front ends of the ribs move upward and slightly anteriorly, which makes them more horizontal. This elevates the rib cage, making it wider and thicker. The rib cage also shortens (top to bottom) when inhaling, and the costal angle (skeletal arch) widens. The last two ribs move only minimally.

There is slight movement at the **sternocostal articulations** where the costal cartilages meet the sternum, as well as at the **costochondral articulations** where the ribs attach to their cartilages. The costal cartilages are also capable of twisting and bending along their lengths. All these movements allow the rib cage to change shape during breathing.

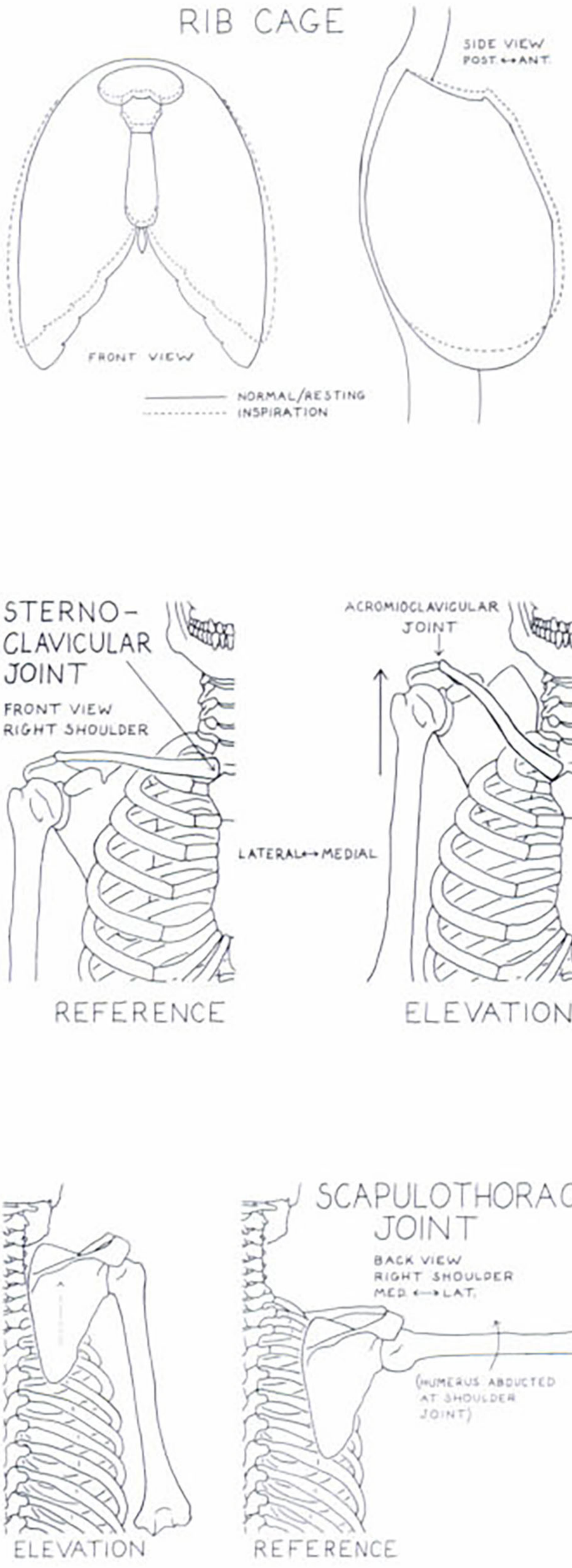
Joints—Appendicular Skeleton

The **appendicular skeleton** consists of the bones of the upper and lower extremities (the arm and leg).

UPPER EXTREMITY The *SHOULDER GIRDLE,* consisting of the scapula, clavicle, and manubrium of the sternum, connects the skeleton of the arm to the body. The only bony articulation of the shoulder girdle to the axial skeleton is at the **sternoclavicular joint**—a *plane joint* where the medial end of the clavicle articulates with the manubrium of the sternum. A flat articular disc is situated within the joint, between the clavicle and the manubrium (the joint is actually a double plane joint—the clavicle doesn't directly touch the manubrium). The clavicle can be raised and lowered, brought forward and back, and circumducted, as its medial end pivots at the manubrium.

The **acromioclavicular joint,** where the lateral end of the clavicle articulates with the inner border of the acromion of the scapula, also is a *plane joint.* It is capable of only a very small amount of motion in order to accommodate the small amount of movement that usually takes place between the scapula and the clavicle when the shoulder is moved. Whenever the clavicle moves, so does the scapula. The scapula, however, can move (rotate) without the clavicle moving.

Although not a true joint, the scapula articulates with the rib cage at the **scapulothoracic "joint."** This articulation is capable of extensive


RIB CAGE
FRONT VIEW
SIDE VIEW
POST. ↔ ANT.
NORMAL/RESTING
INSPIRATION
STERNO-
CLAVICULAR
JOINT
FRONT VIEW
RIGHT SHOULDER
LATERAL ↔ MEDIAL
REFERENCE
ACROMIOCLAVICULAR
JOINT
ELEVATION
SHOULDER GIRDLE
AWAY FROM MIDLINE
TOWARD MIDLINE
PIVOT
RETRACTED
ADVANCED
TOP VIEW
POST.
ANT.
REFERENCE
SCAPULOTHORACIC
JOINT
BACK VIEW
RIGHT SHOULDER
MED. ↔ LAT.
(HUMERUS ABDUCTED
AT SHOULDER
JOINT)
ELEVATION
REFERENCE
(HUMERUS
ABDUCTED AT
SHOULDER JOINT)
ROTATION

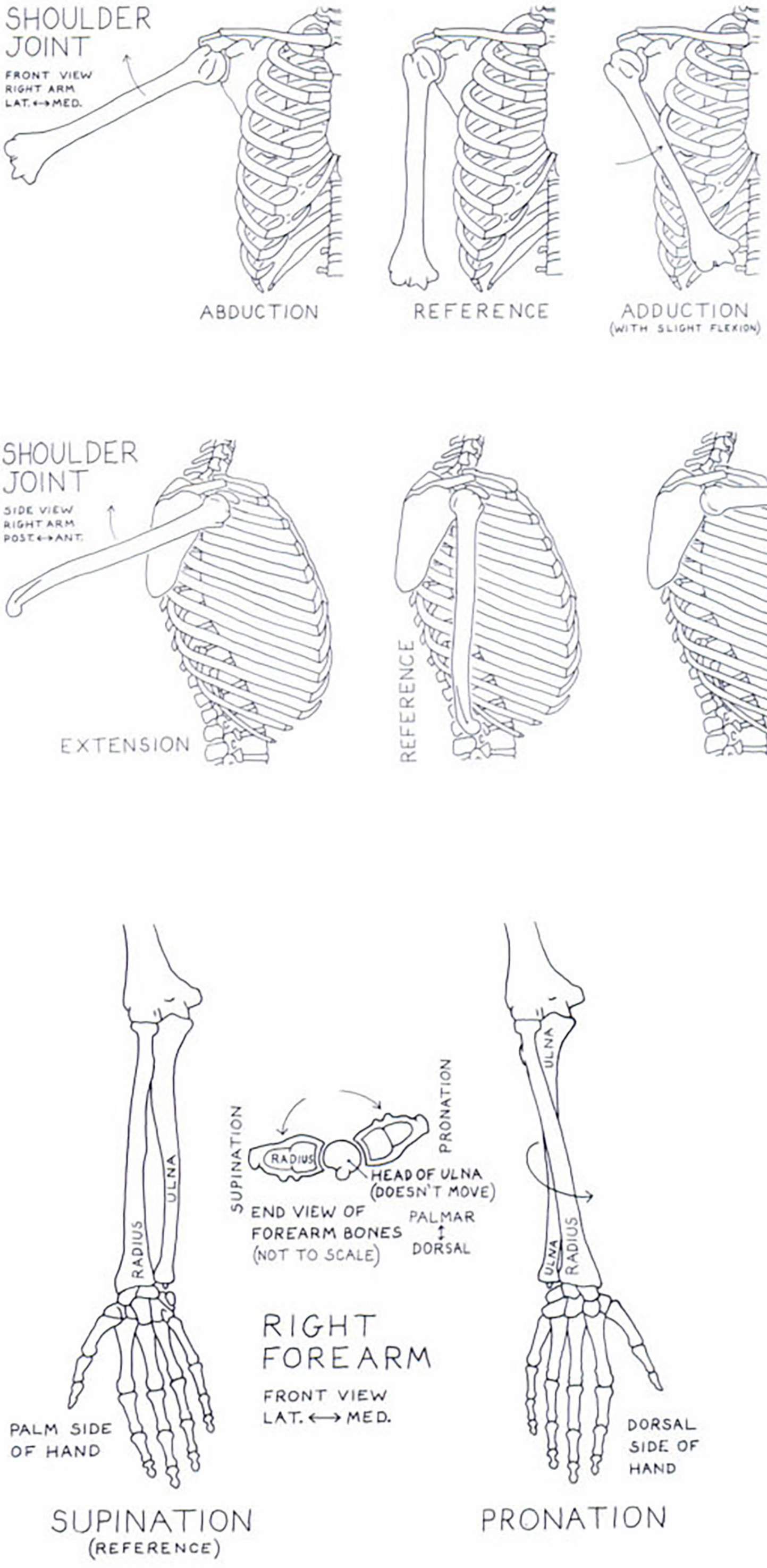
motion as the slightly concave deep surface of the scapula glides over the convex form of the rib cage. As the shoulder moves, two intervening sheets of muscles between the scapula and the rib cage slide against one another (the subscapularis slides against the serratus anterior, and the serratus anterior slides against the thoracic wall). The scapula can be raised and lowered, moved toward and away from the midline, circumducted, and rotated. Moving the scapula laterally also moves it forward, because it automatically slides along the rounded side of the rib cage toward the front of the body. The scapula can be circumducted so that it traces the perimeter of a circle (a sequence of upward, inward, downward, and outward motion) and rotated whereby the inferior angle moves laterally while the superior angle moves medially. The normal relaxed resting position of the scapula is very close to its lowest position possible on the rib cage.

The large head of the humerus articulates with the relatively small, narrow, and shallow glenoid cavity of the scapula at the *ball-and-socket SHOULDER JOINT*. Because of the shallowness of the glenoid cavity, a great range of motion is possible at the shoulder joint at the expense of stability. The socket is deepened somewhat by a fibrocartilaginous rim attached to the edge of the glenoid cavity. The humerus can be flexed (moved forward), extended (moved back past the trunk), abducted, adducted (often by gravity), circumducted, and rotated on its long axis. It can be flexed further than it can be extended. As the arm is raised to a vertical position and beyond (either abducted to the side or flexed in front), motion takes place at both the shoulder joint between the humerus and scapula and the scapulothoracic joint between the scapula and rib cage (the scapula rotates on the rib cage). Both motions occur simultaneously at the ratio of approximately two-thirds shoulder joint motion to one-third scapular rotation; however, the ratio varies according to the position of the arm at various stages throughout its range of motion. Shoulder joint motion predominates at the onset of abduction from the hanging arm, whereas scapulothoracic joint motion only occurs after the arm has been abducted beyond the horizontal.

PRONATION and *SUPINATION* occur when the distal end of the radius is rotated around the distal head of the ulna. The **anatomical axis of pronation and supination** passes from the head of the radius through the head of the ulna. With the upper extremity in the anatomical position for reference, pronation occurs when the radius is rotated so that the palm of the hand is directed posteriorly; supination directs the palm anteriorly. The proximal end of the radius always remains on the lateral side of the ulna at the elbow while the radius rotates on its long axis. During pronation and supination, *the ulna does not move in relationship to the humerus*, although its distal head may move slightly. This slight side-to-side shifting of the head of the ulna is caused by *rotation of the humerus along its long axis* (motion occurring at the shoulder joint).

With the forearm supinated, the forearm bones are parallel to each other, with the radius lying lateral to the ulna. When pronated, the radius crosses the ulna obliquely, its proximal end remaining lateral to the ulna and its distal end now medial to the distal end of the ulna. The horizontal axis through the wrist (through the styloid processes of the radius and ulna) in relationship to the axis through the epicondyles of the humerus indicates the degree of pronation or supination of the forearm, regardless of the position of the entire arm in space. Pronation and supination can take place during any degree of flexion or extension of the elbow joint.

Owing to the outward curvature of the shaft of the radius, the interosseous space between the radius and ulna is widest (and oval) at the position midway between pronation and supination. The hand is attached to the distal end of the radius and moves with this end of the radius during pronation and supination.


SHOULDER JOINT
FRONT VIEW
RIGHT ARM
LAT. ↔ MED.
ABDUCTION
REFERENCE
ADDUCTION
(WITH SLIGHT FLEXION)
SHOULDER JOINT
SIDE VIEW
RIGHT ARM
POST. ↔ ANT.
EXTENSION
REFERENCE
NO SCAPULAR MOVEMENT
FLEXION
RADIUS
ULNA
SUPINATION
PRONATION
RADIUS
HEAD OF ULNA
(DOESN'T MOVE)
END VIEW OF
FOREARM BONES
(NOT TO SCALE)
PALMAR
DORSAL
RIGHT
FOREARM
FRONT VIEW
LAT. ⟷ MED.
ULNA
RADIUS
PALM SIDE
OF HAND
DORSAL
SIDE OF
HAND
SUPINATION
(REFERENCE)
PRONATION

At the *ELBOW* there are three separate joints: the humerus with the ulna, the humerus with the radius, and the ulna with the radius.

The trochlea of the humerus articulates within the trochlear notch of the ulna at the **humeroulnar joint,** which is capable of flexion and extension only. It is a *hinge joint* and is very stable because of the close congruency of its articulating surfaces. The olecranon on the back of the ulna halts extension when it hits the humerus. When extension stops, the ulna is usually in line with the humerus (side view); extension past a straight line is termed **hyperextension,** and is commonly seen in the female. When the elbow joint is extended, the top of the olecranon is in line with the level of the medial and lateral epicondyles of the humerus. As the elbow is flexed, the olecranon drops down in relation to these humeral landmarks.

The axis through the trochlea of the humerus is not perpendicular to the axis of the shaft of the humerus, but is directed downward and medially. Because of this, the long axes of the humerus and ulna are not in line with each other (from the front view with the elbow extended), but form an obtuse angle laterally where they meet at the elbow joint. This angle on the outside of the elbow is called the **carrying angle;** it is apparent when the elbow joint is extended and the forearm is supinated and is usually more acute in the female. When the forearm is pronated, however, the distal end of the radius moves toward the medial side of the distal end of the ulna, shifting the axis of the *overall mass of the forearm* so that it comes *in line* with the axis of the overall mass of the upper arm.

At the **humeroradial joint,** the head of the radius glides on the surface of the capitulum of the humerus when the elbow joint is flexed and extended, and rotates against it during pronation and supination. It is considered a *plane joint*. The small space between the capitulum and the head of the radius may be seen as a small dimple on the outer surface of the elbow when the elbow is fully extended.

At the **proximal radioulnar joint**—a *pivot joint*—the head of the radius rotates against the lateral side of the ulna within the **annular ligament.** The annular ligament is formed by a ligamentous ring that surrounds the head of the radius and is attached to the lateral side of the ulna. During flexion and extension at the elbow joint with no pronation or supination, there is no movement at the proximal radioulnar joint. When the forearm is pronated and supinated, there is movement as the head of the radius rotates against the side of the ulna.

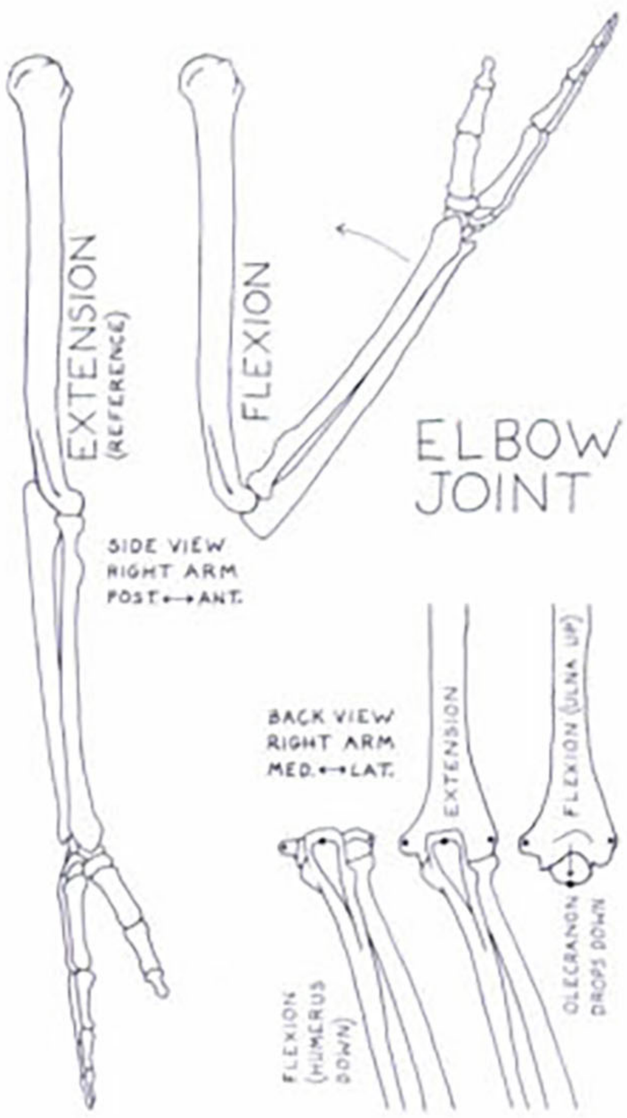
The distal end of the radius rotates around the distal end, or head, of the ulna at the **distal radioulnar joint,** also a *pivot joint*. The medial side of the radius is notched to receive the spherical head of the ulna, and as the radius slides around the head of the ulna, various surfaces of the head of the ulna become exposed.

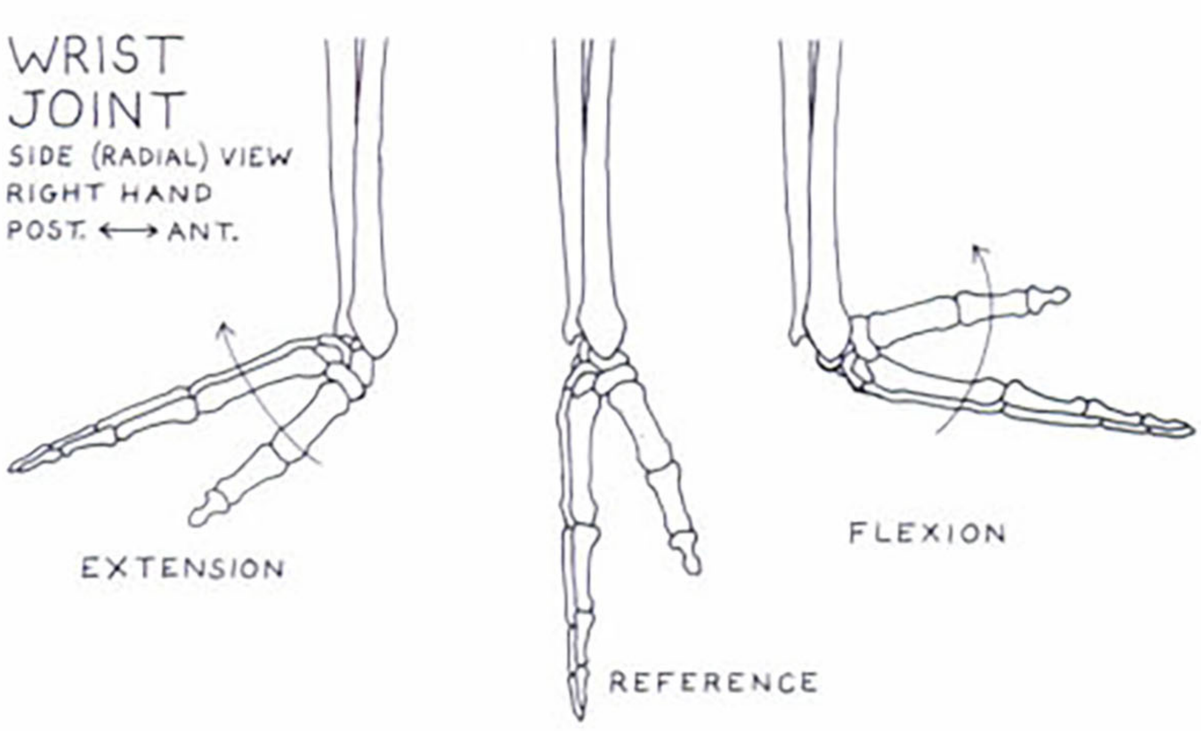
The *WRIST JOINT* is the articulation of the carpus with both the distal end of the radius and the articular disc at the end of the ulna. The head of the ulna does not directly participate in the formation of the wrist joint—only the intervening articular disc does, and minimally so at this *plane joint*. The concave articular surface at the distal end of the radius forms a narrow, shallow socket which receives the convex proximal row of carpal bones. It is an *ellipsoid joint* and is the major articulation of the wrist. It is capable of flexion and extension, radial and ulnar deviation (abduction and adduction in the anatomical position), and circumduction. No rotation is possible. The wrist can be extended and flexed almost to a right angle with the forearm; it can usually be flexed slightly more than it can be extended. If the fingers are extended, the wrist can be flexed further than when they are clenched into a fist. Ulnar deviation is greater than radial deviation because the styloid process of the ulna is located at a more proximal level than is the styloid process of the radius, both of which stop wrist motion when coming in contact with the carpus. The axis of radial and ulnar deviation passes from front to back through the capitate bone of the carpus.

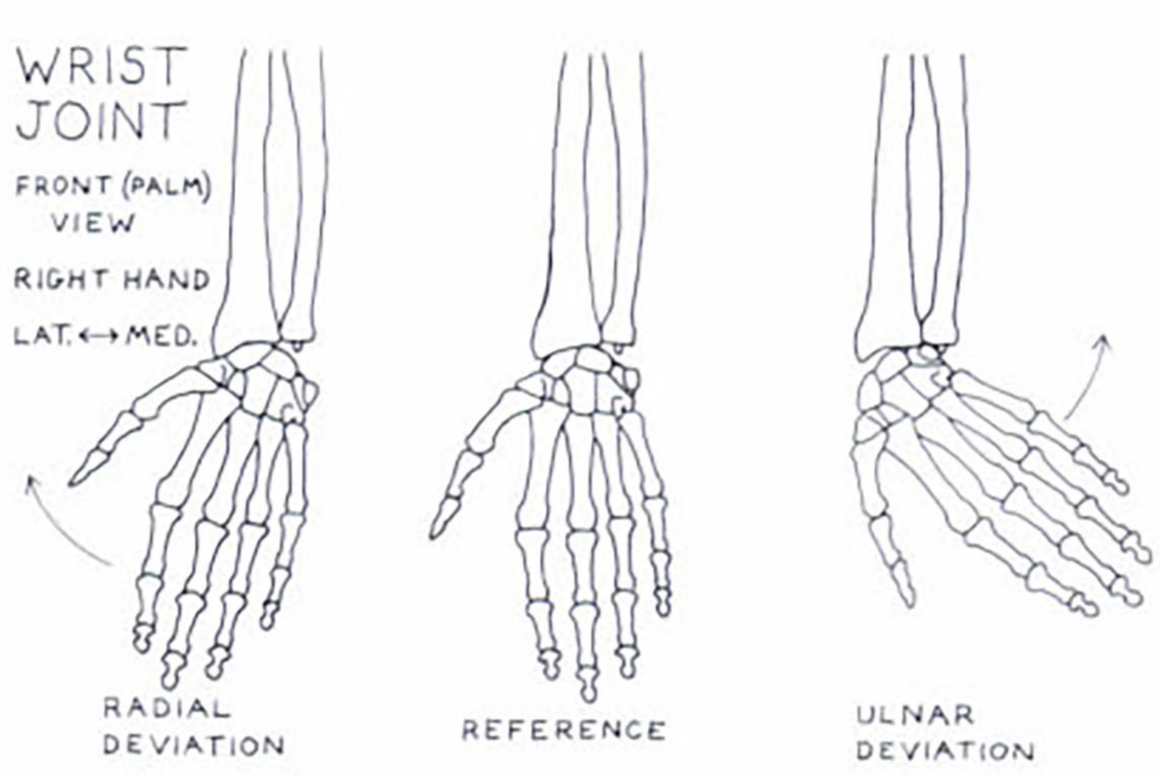
In the *HAND,* there is a small degree of motion among all the **carpal bones** at their *plane joints*. When the wrist is flexed and extended, motion within the carpus takes place between its proximal and distal rows—more so during extension.

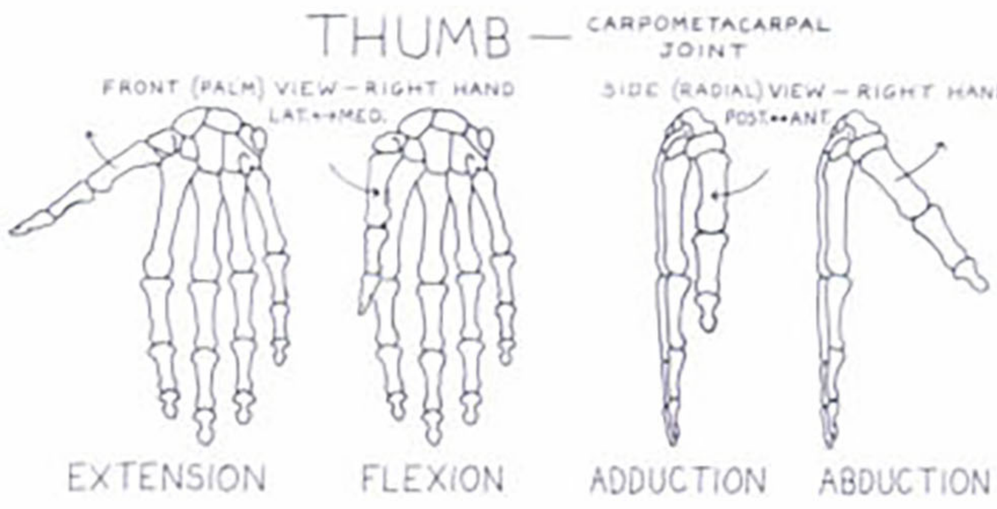
The **carpometacarpal joints of fingers two through five,** where the metacarpals articulate with the carpal bones, are *plane joints*. There is limited motion at these joints: the little finger has the greatest amount of motion, then the ring finger, next the index finger, and finally the middle finger, which practically has no motion at all. These movements allow the palm to be cupped or flattened.

The **carpometacarpal joint of the thumb,** where the metacarpal of the thumb articulates with the trapezium of the carpus, is a *saddle joint;* it is noted for its extensive range of motion. The metacarpal of the thumb can be flexed, extended, abducted, adducted, and circumducted. Only minimal rotation is possible, but it is quite important because it allows the thumb to rotate so its tip can come in contact with the tips of the other fingers, referred to as


EXTENSION
(REFERENCE)
FLEXION
ELBOW
JOINT
SIDE VIEW
RIGHT ARM
POST.←→ANT.
BACK VIEW
RIGHT ARM
MED.←→LAT.
EXTENSION
FLEXION (ULNA UP)
FLEXION
(HUMERUS
DOWN)
OLECRANON
DROPS DOWN


WRIST
JOINT
SIDE (RADIAL) VIEW
RIGHT HAND
POST. ⟷ ANT.
EXTENSION
REFERENCE
FLEXION


WRIST
JOINT
FRONT (PALM)
VIEW
RIGHT HAND
LAT. ↔ MED.
RADIAL
DEVIATION
REFERENCE
ULNAR
DEVIATION


THUMB — CARPOMETACARPAL
JOINT
FRONT (PALM) VIEW — RIGHT HAND
LAT.↔MED.
SIDE (RADIAL) VIEW — RIGHT HAND
POST.↔ANT.
EXTENSION
FLEXION
ADDUCTION
ABDUCTION

opposition. Opposition can be either fingertip to fingertip or pad to pad.

The **metacarpophalangeal joints** of fingers two through five have extensive motion, while that of the thumb has less. These joints are *ellipsoid joints*, where the rounded head of each metacarpal articulates with the concave base of a corresponding proximal phalanx. The metacarpophalangeal joint of the thumb is very shallow and functions more as a hinge joint, permitting a relatively small degree of flexion and extension. The other four metacarpophalangeal joints permit flexion, extension, abduction, and adduction (also referred to as radial and ulnar deviation, especially for the middle finger, which is considered the midline of the hand), and circumduction. No voluntary rotation is possible. Fingers two through five can be flexed to 90° at the metacarpophalangeal joints and can be extended just past a straight line with the metacarpals (hyperextension). These fingers can be further hyperextended if the interphalangeal joints are flexed. When the fingers are fully flexed at the metacarpophalangeal joints, abduction (or spreading) is not possible. When flexing the fingers, the bases of the phalanges of fingers two through five slide around to the palmar surface of the metacarpal heads, exposing the metacarpals' *rounded* distal extremities, referred to as the **proximal knuckle row.**

The **interphalangeal joints** are *hinge joints* capable only of flexion and extension. The thumb has one such joint, while the other fingers have two each. As the fingers are flexed, the base of a phalanx rotates around to the palmar side of the distal end of the articulating phalanx, exposing its squared-off articular condyles. The interphalangeal joints of fingers two through five normally can be extended until the phalanges are straight; however, that of the thumb can typically be hyperextended slightly. The proximal interphalangeal joints of fingers two through five can be flexed to an angle more acute than 90°; the distal interphalangeal joints do not quite reach a right angle. The single interphalangeal joint of the thumb can be flexed to around 90°. The proximal interphalangeal joints of fingers two through five are referred to as the **distal knuckle row.**

When the hand is relaxed, the fingers all tend to flex, and the fingertips converge.

LOWER EXTREMITY The *PELVIC GIRDLE* is the large bony ring made up of the two hip bones attached to the sacrum in back at the **sacroiliac joints** and to each other in front at the **pubic symphysis.** There is virtually no movement at these articulations.

The head of the femur articulates in the acetabulum on the side of the pelvis to form the *HIP JOINT*. The acetabulum is a deep socket which provides great stability in supporting the weight of the body while still allowing an extensive range of motion, though less so than that found at the shoulder joint. The hip joint is a *ball-and-socket joint,* permitting flexion, extension, abduction, adduction, circumduction, and rotation of the femur.

Rotation of the femur occurs on an axis that passes between the head of the femur and the medial condyle of the femur, not along its shaft. Therefore, during medial and lateral rotation of the femur, the greater trochanter, which projects away from the head of the femur by the length of the femoral neck, travels along an arc as it moves forward and backward. The greater trochanter also moves upward and downward as the femur is abducted and adducted. When the femur is fixed (as when standing on one leg), the pelvis then pivots around the head of the femur.

Extension of the femur at the hip joint terminates when the femur extends 10°–15° past a vertical line (in the normal erect position), as the **iliofemoral** or **Y ligament** on the front of the hip joint is pulled taut. *If the knee is flexed,* flexion of the femur at the hip joint stops when the thigh touches the trunk. *If the knee is extended,* flexion of the femur at the hip joint stops when the hamstring muscles on the back of the thigh are pulled tight. Hip flexion therefore has a lesser range of motion when the knee is extended than when it is flexed.

THUMB
OUTSIDE (RADIAL) VIEW
RIGHT HAND

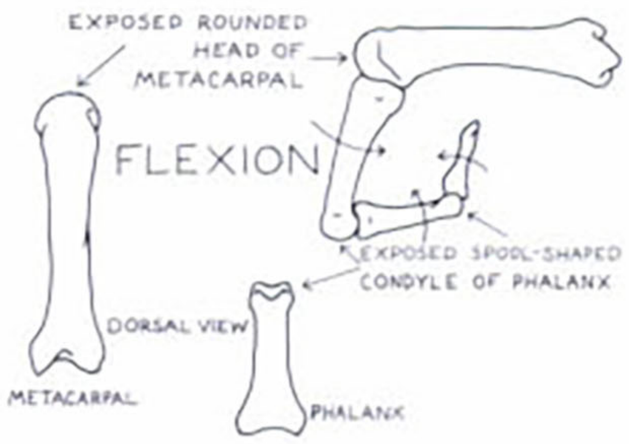
REFERENCE
(SLIGHT HYPEREXTENSION AT INTERPHALANGEAL JOINT)

FLEXION

INDEX FINGER
OUTSIDE (RADIAL) VIEW
RIGHT HAND

HYPEREXTENSION AT METACARPOPHALANGEAL JOINT

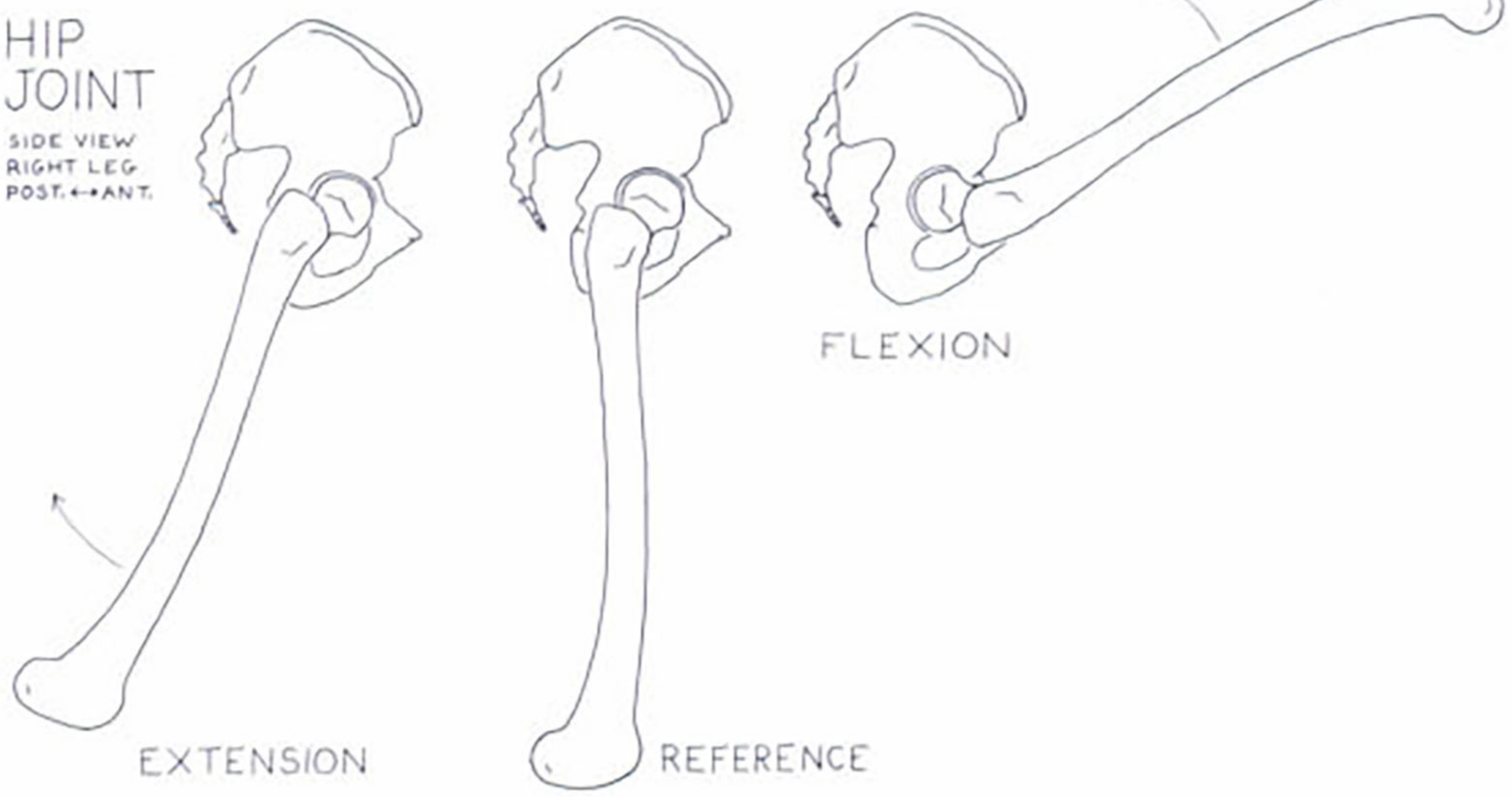
REFERENCE



FLEXION

METACARPO-PHALANGEAL JOINT
FRONT (PALM) VIEW
RIGHT HAND
LAT. ⟷ MED.

HIP JOINT
SIDE VIEW
RIGHT LEG
POST. ⟷ ANT.

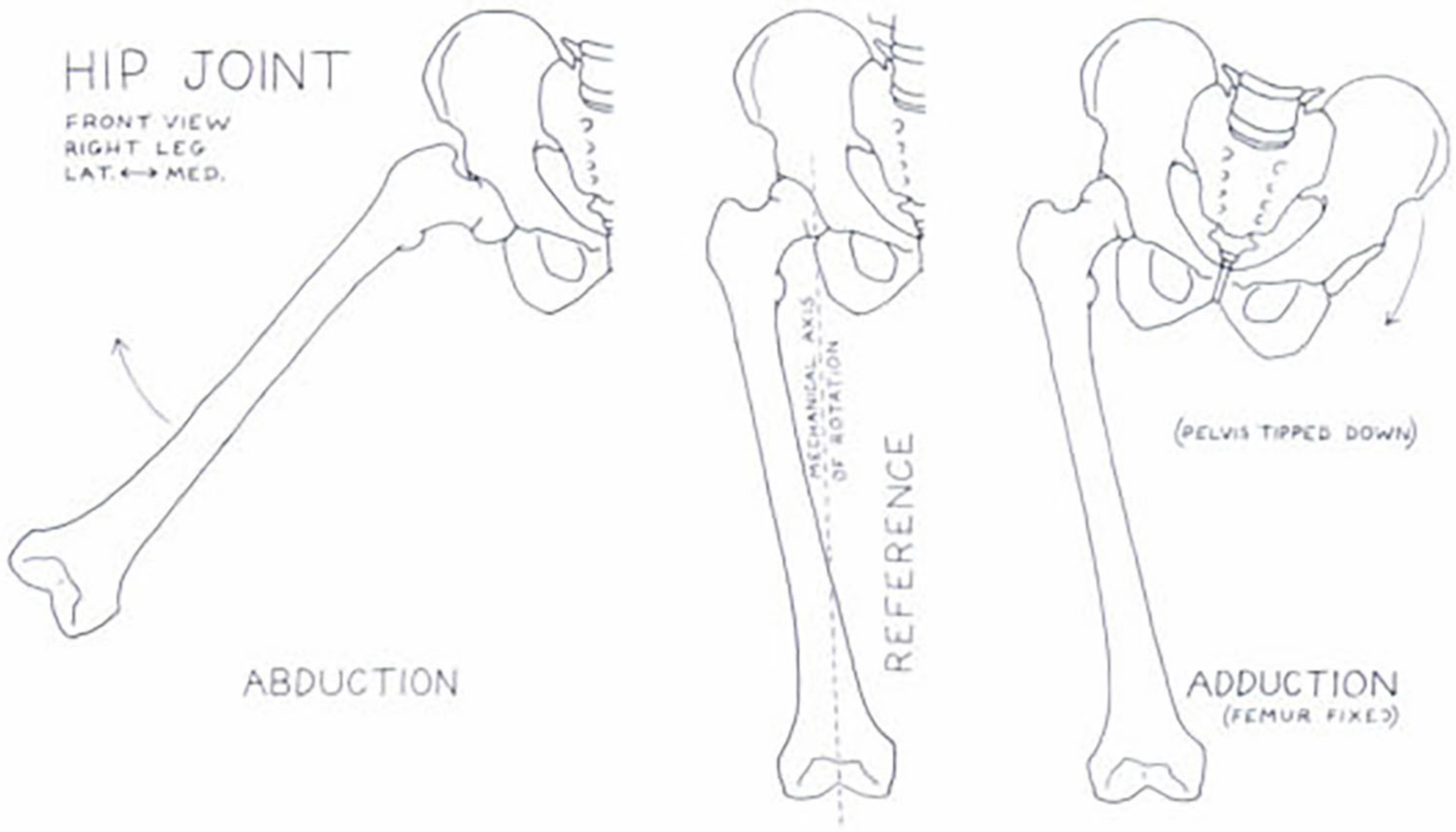


EXTENSION

REFERENCE

FLEXION

HIP JOINT
FRONT VIEW
RIGHT LEG
LAT. ⟷ MED.



ABDUCTION

REFERENCE

(PELVIS TIPPED DOWN)

ADDUCTION
(FEMUR FIXED)

The femur articulates with the tibia at the *KNEE JOINT*, which is the largest joint in the body. The fibula does not participate in the formation of this joint. The knee joint contains two separate *condyloid joints:* the medial condyle of the femur articulates with the medial condyle of the tibia, and the lateral condyle of the femur articulates with the lateral condyle of the tibia. The articular surfaces of the femoral condyles are rounded, whereas those of the tibial condyles are flatter, resulting in small surface areas of contact between the two bones. This design is unstable. Stability at the knee joint is provided by strong ligaments, muscles, and tendons which surround and secure the joint.

The knee resembles a hinge joint (it predominantly flexes and extends); however, a small amount of rotation also takes place. With the tibia fixed, flexion of the knee joint involves the rolling of the femoral condyles on top of the tibial condyles while they simultaneously slide forward (during flexion) or backward (during extension). When the knee reaches full extension, rotation at the joint automatically locks the knee as the ligaments are pulled tight. The knee is therefore most stable in the extended position. Conversely, in order to then flex the extended knee joint, the joint must be rotated in the opposite direction to unlock it. The tibia *ex*ternally rotates when the lower leg is *ex*tended, or, if the foot is fixed on the ground during extension, the femur then rotates medially (internally). Voluntary medial and lateral rotation of the tibia is possible only after the knee has been flexed. The extent of rotation at the knee joint is small, and movement is most noticeable at the subcutaneous head of the fibula when the knee is first flexed and then rotated in both directions.

Extension of the knee joint stops as the ligaments are tightened, placing the femur in a straight line with the tibia. Occasionally the bones continue past a straight line, and the knee is then hyperextended. Flexion stops when the calf muscles come in contact with the hamstring muscles on the back of the thigh. In life, the gap between the condyles of the femur and the tibia can best be seen on either side of the patellar ligament, toward the medial and lateral sides of the knee (especially on the medial side), after the knee joint has been flexed. The cordlike **fibular collateral ligament** on the outside of the knee joint, connecting the posterior part of the lateral epicondyle of the femur to the outer surface of the head of the fibula, is sometimes seen on the surface just anterior to the short head of the biceps femoris muscle.

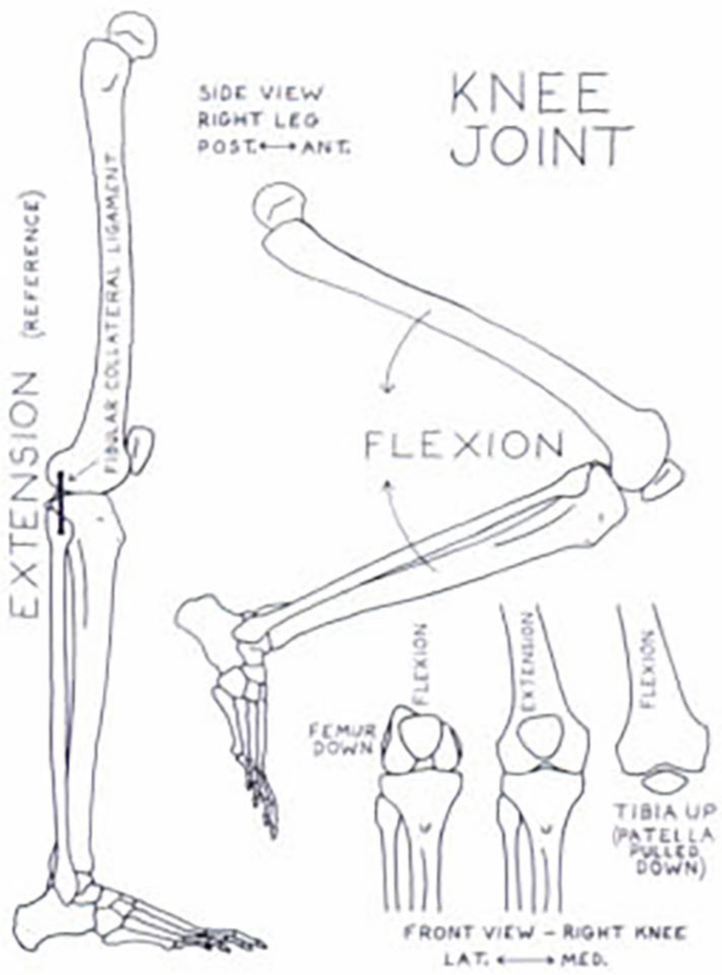
In the standing position with the legs straight and the knees touching (front view), the oblique femur meets the vertical tibia at the knee joint and the two bones form an obtuse angle on the outside of the knee. Because the female has a wider pelvis, the femurs are consequently placed further apart superiorly. This places the female femur in a more oblique position than that of the male, and the angle it makes with the tibia is more acute.

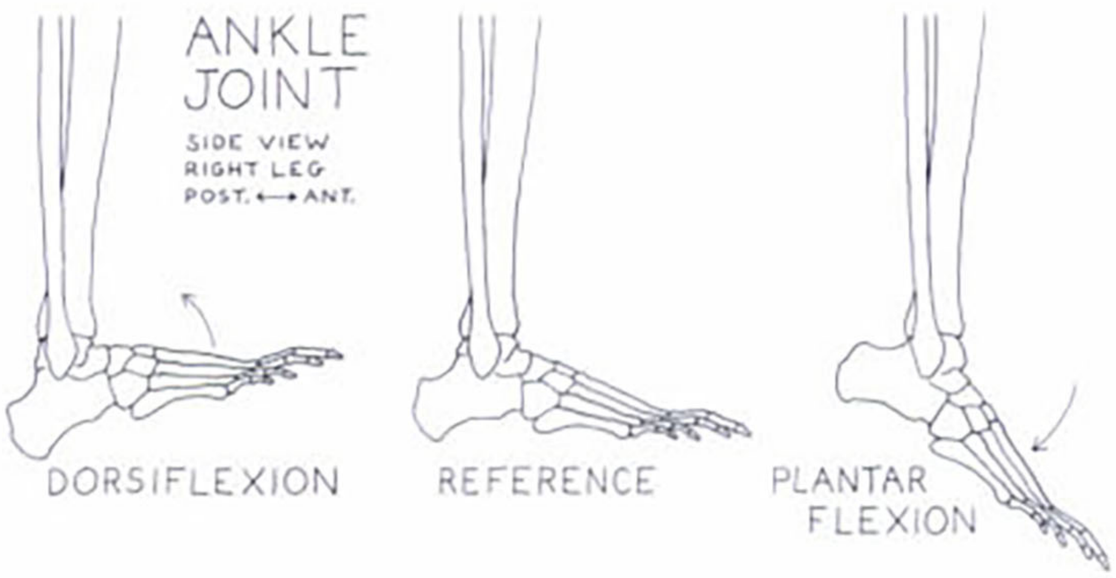
Because the *PATELLA* is attached to the tibial tuberosity by the inelastic patellar ligament, the distance between the patella and the tibia remains unchanged during motion at the knee joint. As the knee is flexed, the tibia slides around from the distal surfaces of the condyles of the femur to their posterior surfaces, pulling the patella round with it. The patella slides in the groove between the medial and lateral condyles of the femur, and this articulation is considered a *saddle joint*. The longitudinal ridge on the back of the patella keeps it in this groove. When the knee is fully extended in the standing position with the thigh muscles tensed, the patellar ligament remains taut. However, when these muscles are relaxed, the patella drops down slightly and the ligament slackens a bit.

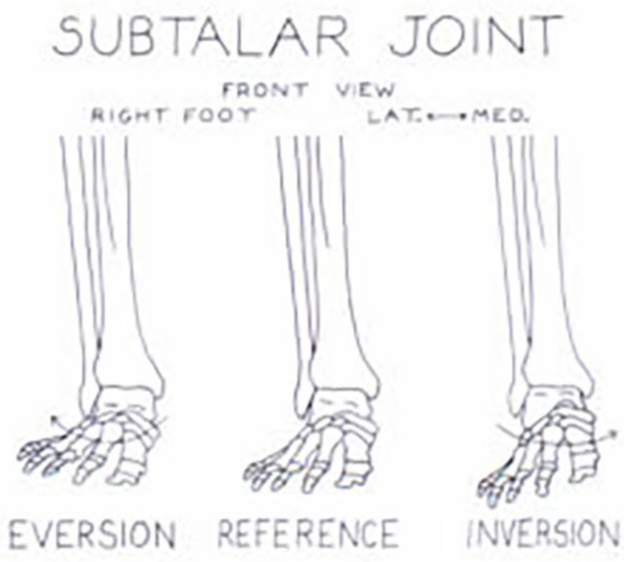
The tibia articulates with the fibula at the two *TIBIOFIBULAR JOINTS*. The **proximal tibiofibular joint** between the head of the fibula and the posterior part of the outer surface of the lateral condyle of the tibia is a *plane joint* which permits a minimal amount of gliding. The **distal tibiofibular joint** is a *fibrous joint* that pivots minimally. At the distal joint, the lateral surface of the distal expansion of the tibia is notched to receive the lateral malleolus of the fibula. The slight movement in both tibiofibular joints is necessary for proper ankle joint functioning (these movements are not seen on the surface).

At the *ANKLE JOINT* (**talocrural joint**), the talus of the foot articulates with the socket formed by the distal ends of the tibia and fibula. This joint is a *hinge joint* which permits only **dorsiflexion** (lifting the foot) and **plantar flexion** (pointing the toe). The angle of dorsiflexion can be slightly more acute than 90°; plantar flexion is greater than dorsiflexion.

Within the tarsus of the *FOOT*, the joint with the greatest amount of motion is the **subtalar joint.** This is the articulation of the posterior portion of the talus with the calcaneus below; it is considered a *plane joint*. The subtalar joint permits **inversion** (facing the sole medially) and **eversion** (facing the sole laterally) of the foot. Anteriorly, the talus articulates again with the calcaneus and with the posterior surface of the


KNEE JOINT
SIDE VIEW
RIGHT LEG
POST. ⟷ ANT.
EXTENSION (REFERENCE)
FIBULAR COLLATERAL LIGAMENT
FLEXION
FEMUR DOWN
FLEXION
EXTENSION
FLEXION
TIBIA UP (PATELLA PULLED DOWN)
FRONT VIEW – RIGHT KNEE
LAT. ⟷ MED.


ANKLE JOINT
SIDE VIEW
RIGHT LEG
POST. ⟷ ANT.
DORSIFLEXION
REFERENCE
PLANTAR FLEXION


SUBTALAR JOINT
FRONT VIEW
RIGHT FOOT
LAT. ⟷ MED.
EVERSION
REFERENCE
INVERSION

navicular. This joint is the **talocalcaneonavicular joint,** which is considered to be a *ball-and-socket joint*. Here, the concave surface of the navicular glides on the convex anterior surface of the talus during inversion and eversion of the foot. Because both the talocalcaneonavicular and subtalar joints move when the foot is inverted and everted, this entire joint complex can be called the **"talotarsal" joint.** Movements at both the ankle and talotarsal joints allow the foot to accommodate surface irregularities when walking over uneven terrain.

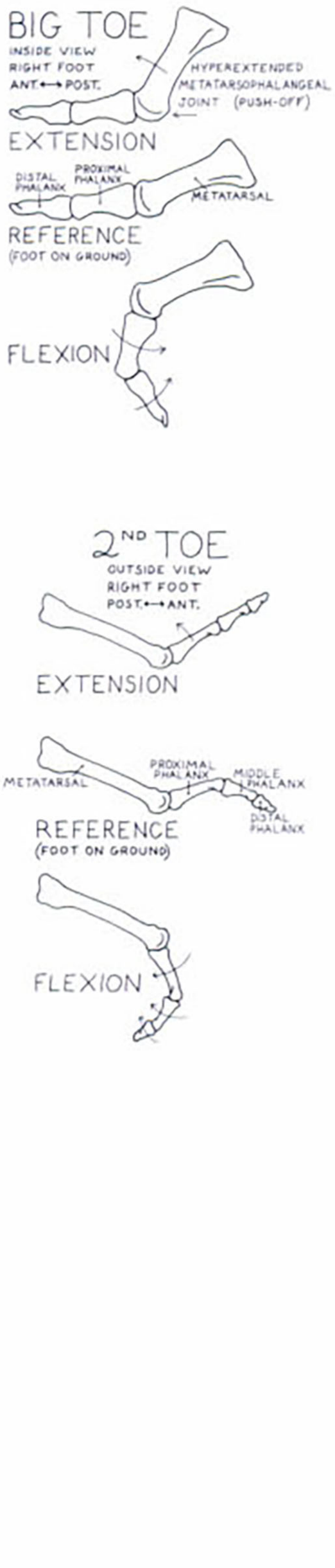
The axis of inversion/eversion lies on an axis that is directed forward, medially, and downward; therefore, during inversion of the talotarsal joint, the foot is also plantar flexed and the front of the foot moves toward the midline (adduction). Conversely, during eversion, the foot is also dorsiflexed and the front abducted. In facing the sole of the foot directly medially or laterally, inversion must be accompanied by dorsiflexion, and eversion with plantar flexion. Motion therefore takes place at both the ankle and talotarsal joints.

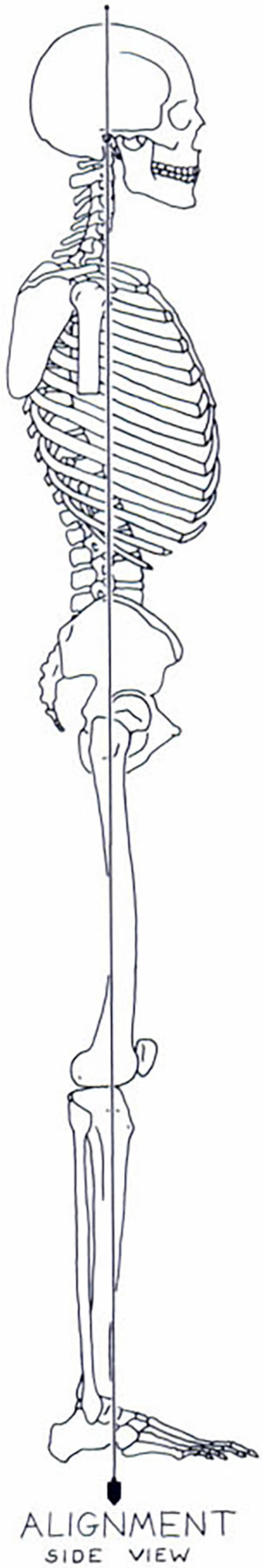
The remaining **intertarsal joints** are *plane joints*, permitting small amounts of gliding and rotational movements. The **tarsometatarsal joints** between the tarsal bones and the bases of the metatarsals are also *plane joints*, and they too permit minimal motion. Although the motion within the tarsus and between the tarsals and the metatarsals is limited, it does impart a resilience to the foot skeleton which allows it to act as a shock absorber when the weight of the body makes impact against the ground. It also allows for the raising and lowering of the arches, caused by general flexion or extension within the foot or by rotation of the front portion of the foot around its long axis.

The **metatarsophalangeal joints** between the metatarsals and the phalanges are *ellipsoid joints*, which permit flexion, extension, abduction, and adduction. Flexion exposes the rounded distal heads of the metatarsals as the phalanges slide around to their inferior or plantar surfaces. The toes can be hyperextended considerably at this joint, which normally occurs in walking just before the posterior foot pushes off from the ground. Abduction spreads the toes apart. A line passing through the second toe acts as reference for abduction and adduction. The toes converge as they are flexed, and then cannot voluntarily be spread apart.

The **interphalangeal joints** are *hinge joints*, allowing only flexion and extension. The interphalangeal joint of the big toe and the proximal interphalangeal joints of toes two through five can be extended roughly until they are straight. The distal interphalangeal joints of toes two through five can be hyperextended. The middle and distal phalanges of the little toe are sometimes fused together.

The line from the **center of gravity** (center of mass) of the standing figure falls behind the hip joint, in front of the knee joint, and in front of the ankle joint. Because extension of the hip joint is terminated by the femoral ligament on the front of the joint, and because extension of the knee joint is terminated by ligaments toward the back of the joint, gravity locks these joints in place in the standing figure, reducing the amount of muscular energy needed to maintain this position. The center of gravity falls just in front of the ankle, and the back of the ankle joint has no ligamentous locking mechanism in the standing position, therefore, the calf muscles work in intermittent contraction to maintain the erect position.


BIG TOE
INSIDE VIEW
RIGHT FOOT
ANT. ⟷ POST.
HYPEREXTENDED
METATARSOPHALANGEAL
JOINT (PUSH-OFF)
EXTENSION
DISTAL PHALANX
PROXIMAL PHALANX
METATARSAL
REFERENCE
(FOOT ON GROUND)
FLEXION
2ND TOE
OUTSIDE VIEW
RIGHT FOOT
POST. ⟷ ANT.
EXTENSION
METATARSAL
PROXIMAL PHALANX
MIDDLE PHALANX
DISTAL PHALANX
REFERENCE
(FOOT ON GROUND)
FLEXION


ALIGNMENT
SIDE VIEW

The muscles listed below are responsible for motion at the joints. Some of the muscles are deep and do not influence surface form; therefore, they are usually not described under artistic anatomy. They are presented here to give a complete listing of those muscles producing joint motion.

Axial Skeleton

TEMPOROMANDIBULAR JOINT *Opened:* Lateral pterygoid; assisted by digastric, mylohyoid, and geniohyoid. *Closed:* Masseter, temporalis, and medial pterygoid. *Protruded:* Masseter and lateral pterygoid. *Retracted:* Posterior fibers of the temporalis. *Displaced laterally:* Lateral pterygoid.

ATLANTO-OCCIPITAL JOINT *Flexion:* Longus capitis and rectus capitis anterior. *Extension:* Rectus capitis posterior major and minor, obliquus capitis superior, semispinalis capitis, splenius capitis, posterior fibers of sternocleidomastoid, and upper fibers of trapezius. *Lateral bending:* Rectus capitis lateralis; assisted by trapezius, splenius capitis, semispinalis capitis, and sternocleidomastoid (all of the same side acting together).

ATLANTOAXIAL JOINTS *Rotation:* Sternocleidomastoid and semispinalis capitis of one side acting with longus capitis, splenius, longissimus capitis, rectus capitis posterior major, and obliquus capitis inferior of the other side.

VERTEBRAL COLUMN *Flexion:* Sternocleidomastoid, longus capitis, longus colli, scalenes, the abdominal muscles, and psoas major. *Extension:* Erector spinae; assisted by splenius, semispinales, and multifidi. *Lateral bending:* Erector spinae, splenius, scalenes, quadratus lumborum, and psoas major (of one side only). *Rotation:* Sternocleidomastoid, splenius, longus capitis, scalenes, multifidus, rotatores, semispinalis capitis, and the abdominal muscles (of one side only).

RIBCAGE *Inspiration* (lifts ribs): *Quiet:* External intercostals (diaphragm protrudes abdomen in quiet inspiration, but doesn't lift ribs). *Forced:* Sternocleidomastoid, scalenes, levatores costarum, serratus posterior superior, and pectoralis minor. *Expiration* (lowers ribs): *Quiet:* Elastic recoil and abdominal muscles. *Forced:* Abdominal muscles, internal intercostals, serratus posterior inferior, and quadratus lumborum.

Appendicular Skeleton—Upper Extremity

SHOULDER GIRDLE *Elevation:* Upper fibers of trapezius, levator scapulae, clavicular head of sternocleidomastoid; assisted by the rhomboids. *Depression:* Pectoralis minor, lower fibers of trapezius, serratus anterior, and pectoralis major and latissimus dorsi (indirectly via the humerus); assisted by subclavius. *Protracted:* Serratus anterior, pectoralis minor, and pectoralis major. *Retracted:* Rhomboids, middle and lower fibers of trapezius, and latissimus dorsi. *Rotation:* Glenoid cavity facing upward: Trapezius and lower fibers of serratus anterior. Glenoid cavity facing downward: Rhomboids, levator scapulae, pectoralis minor, pectoralis major, and latissimus dorsi.

SHOULDER JOINT *Flexion:* Clavicular part of pectoralis major (sternocostal fibers of pectoralis major only when the arm has been fully extended past the trunk), anterior fibers of deltoid, and coracobrachialis; assisted by biceps brachii (when elbow is flexed). *Extension:* Latissimus dorsi, posterior fibers of deltoid, teres major, long head of triceps (when the elbow is extended), and sternoclavicular fibers of pectoralis major (when the arm has already been flexed in front of the body). *Abduction:* Deltoid and supraspinatus. *Adduction:* Pectoralis major, latissimus dorsi, and teres major; assisted by coracobrachialis and long head of triceps, as well as the posterior fibers of deltoid when the arm is near the side of the body. *Lateral rotation:* Infraspinatus, teres minor, and posterior fibers of deltoid. *Medial rotation:* Subscapularis, latissimus dorsi, teres major, pectoralis major, and anterior fibers of deltoid.

ELBOW JOINT *Flexion:* Biceps brachii and brachialis; assisted by brachioradialis, extensor carpi radialis longus, and pronator teres. *Extension:* Triceps and anconeus.

FOREARM *Pronation:* Pronator teres and pronator quadratus; assisted by flexor carpi radialis. *Supination:* Biceps brachii and supinator.

WRIST JOINT *Flexion:* Flexor carpi radialis, flexor carpi ulnaris, and palmaris longus; assisted by flexor digitorum superficialis and flexor digitorum profundus (when the fingers are extended), flexor pollicis longus, and abductor pollicis longus. *Extension:* Extensor carpi radialis longus, extensor carpi radialis brevis, and extensor carpi ulnaris; assisted by extensor digiti minimi, extensor indicis, extensor pollicis longus, and extensor digitorum (when the fingers are flexed). *Ulnar deviation:* Flexor carpi ulnaris and extensor carpi ulnaris. *Radial deviation:* Abductor pollicis longus and extensor pollicis brevis; assisted by extensor carpi radialis longus, extensor carpi radialis brevis, flexor carpi radialis, and extensor pollicis longus.

CARPOMETACARPAL JOINT OF THE THUMB *Flexion:* Flexor pollicis longus, flexor

pollicis brevis, and opponens pollicis. *Extension:* Extensor pollicis longus, extensor pollicis brevis, and abductor pollicis longus. *Abduction:* Abductor pollicis longus and abductor pollicis brevis; assisted by opponens pollicis. *Adduction:* Adductor pollicis and extensor pollicis longus. *Opposition:* Opponens pollicis, flexor pollicis brevis, and abductor pollicis brevis; assisted by flexor pollicis longus and adductor pollicis.

METACARPOPHALANGEAL JOINTS OF THE MEDIAL FOUR FINGERS *Flexion:* Flexor digitorum superficialis, flexor digitorum profundus, lumbricals, and both sets of interossei; assisted by flexor digiti minimi and abductor digiti minimi in the little finger. *Extension:* Extensor digitorum; assisted by extensor indicis in the index finger and extensor digiti minimi in the little finger. *Abduction:* Dorsal interossei, abductor digiti minimi and flexor digiti minimi in the little finger, and long extensor tendons (as the fingers are extended). *Adduction:* Palmar interossei and long flexor tendons (as the fingers are flexed).

METACARPOPHALANGEAL JOINT OF THE THUMB *Flexion:* Flexor pollicis longus, flexor pollicis brevis, and adductor pollicis; assisted by abductor pollicis brevis. *Extension:* Extensor pollicis longus and extensor pollicis brevis.

INTERPHALANGEAL JOINTS OF THE MEDIAL FOUR FINGERS *Flexion:* Flexor digitorum superficialis acting on the proximal joint only and flexor digitorum profundus acting on both the proximal and distal joints. *Extension:* Lumbricals, interossei, and extensor digitorum.

INTERPHALANGEAL JOINT OF THE THUMB *Flexion:* Flexor pollicis longus. *Extension:* Extensor pollicis longus, as well as abductor pollicis brevis and adductor pollicis (because of their insertion into the tendon of extensor pollicis longus) and extensor pollicis brevis (variable—only if it attaches into the tendon of extensor pollicis longus).

Appendicular Skeleton—Lower Extremity

HIP JOINT *Flexion:* Psoas major, iliacus, and pectineus; assisted by rectus femoris, sartorius, tensor fascia lata, adductor longus, adductor brevis, anterior part of adductor magnus, gracilis, and anterior portion of gluteus minimus. *Extension:* gluteus maximus; assisted by semitendinosus, semimembranosus, long head of biceps femoris, ischial head of adductor magnus, posterior fibers of gluteus medius, piriformes, and obturator internus. *Adduction:* Adductor longus, adductor brevis, obturator portion of adductor magnus, pectineus, and gracilis; assisted by gluteus maximus, obturator externus, quadratus femoris, semitendinosus, semimembranosus, long head of the biceps, ischial head of adductor magnus, and iliopsoas (when the thigh is flexed). *Abduction:* Gluteus medius and gluteus minimus; assisted by tensor fascia lata, piriformes, obturator externus, and sartorius. *Medial rotation* (of femur): Anterior fibers of gluteus minimus, tensor fascia lata, and pectineus; assisted by anterior portion of adductor magnus, adductor longus, adductor brevis, gracilis, and anterior fibers of gluteus maximus. *Lateral rotation* (of femur): Gluteus maximus, posterior fibers of gluteus medius, piriformes, obturator internus, obturator externus, gemellus superior, gemellus inferior, quadratus femoris, iliopsoas, and sartorius.

KNEE JOINT *Flexion:* Biceps femoris, semitendinosus, and semimembranosus; assisted by gracilis, sartorius, gastrocnemius, popliteus, and plantaris. *Extension:* Quadriceps femoris. *Lateral rotation* (of tibia): Biceps femoris. *Medial rotation* (of tibia): Popliteus and semitendinosus; assisted by semimembranosus, sartorius, and gracilis.

ANKLE JOINT *Plantar flexion:* Gastrocnemius and soleus; assisted by plantaris, tibialis posterior, flexor digitorum longus, and flexor hallucis longus. *Dorsiflexion:* Tibialis anterior; assisted by extensor digitorum longus, peroneus tertius, and extensor hallucis longus.

TALOTARSAL JOINT *Inversion:* Tibialis anterior and tibialis posterior; assisted by flexor digitorum longus, extensor hallucis longus, and flexor hallucis longus. *Eversion:* Peroneus longus, peroneus brevis, peroneus tertius, and extensor digitorum longus.

METATARSOPHALANGEAL JOINTS OF THE LATERAL FOUR TOES *Flexion:* Flexor digitorum longus, flexor digitorum brevis; assisted by the lumbricals, both sets of interossei, the quadratus plantae, and the flexor digiti minimi brevis and abductor digiti minimi in the little toe. *Extension:* Extensor digitorum longus; assisted by extensor digitorum brevis (except the little toe). *Abduction:* Dorsal interossei; abductor digiti minimi in the little toe. *Adduction:* Plantar interossei.

METATARSOPHALANGEAL JOINT OF THE BIG TOE *Flexion:* Flexor hallucis brevis, flexor hallucis longus, abductor hallucis, and adductor hallucis. *Extension:* Extensor hallucis brevis and extensor hallucis longus. *Abduction:* Abductor hallucis. *Adduction:* Adductor hallucis.

INTERPHALANGEAL JOINTS OF THE LATERAL FOUR TOES *Flexion:* Flexor digitorum brevis (proximal joint row), flexor digitorum longus (both joint rows); assisted by quadratus plantae. *Extension:* Extensor digitorum longus; assisted by extensor digitorum brevis in the middle three toes.

INTERPHALANGEAL JOINT OF THE BIG TOE *Flexion:* Flexor hallucis longus. *Extension:* Extensor hallucis longus.

The study of the *MUSCULAR SYSTEM* is called **myology.** The **skeletal** or **voluntary muscles,** also referred to as the **somatic** or **striated muscles,** are the organs of voluntary motion, and by their contraction move the bones and therefore the regions of the body. They produce movement or stabilize body segments, moving or locking the joints as the body requires. They are considered the **muscles of form**—they create surface form. The skeletal muscles constitute about forty percent of body weight.

The fleshy fibers of a muscle belly either attach directly to bone or cartilage or attach by means of a tendon or aponeurosis (a wide, flattened tendon). In a given skeletal muscle, the relationship of the length of the fleshy belly to the length of its tendon varies among individuals, races, and sexes. Sometimes muscles will attach to the surfaces of other muscles or to sheetlike septa between muscle groups. The ends of facial muscles either insert directly into the skin or, more usually, blend with fibers of other facial muscles. Males are more muscular than females—a greater percentage of their total body weight is muscle.

Structure

The smallest unit of a "muscle" is a **muscle fiber,** which is a single muscle cell. Groups of fibers form **bundles,** or **fascicles,** which in turn form a complete muscle **belly** having one or more **heads** of varying shapes and sizes. **Slips** are small muscle bundles. A muscle may be entirely fleshy or it may have tendons at one or both ends. Exercise will increase the thickness of existing muscle fibers, thereby increasing muscle mass, but the number of muscle fibers remains constant.

Muscles may be categorized according to fiber arrangement. Those with **parallel** bundles are sheetlike (rhomboid major) or straplike (sartorius, sternohyoid, rectus abdominis). **Fusiform** muscles taper at both ends and bulge at their center (biceps brachii, semitendinosus, tibialis anterior). When oblique muscle bundles attach along one side of a tendon, like the barbs of a feather attaching to its shaft, they form a **unipennate** (actually a **semipennate**) muscle (extensor digitorum longus, semimembranosus), and when oblique fibers attach to both sides of a central tendon, whether that tendon is on the surface or deep within the belly, they form a **bipennate** muscle (rectus femoris). In these pennate muscles, the part of the tendon that has muscle fibers attaching to it usually shows up as a depression or furrow. If the tendon extends past the end of the belly, it is then often seen as a raised ridge. **Multipennate** muscles, such as the deltoid, have numerous groups of oblique bundles beginning and ending on several different tendons, which creates a braided effect. A muscle that converges from a wide area to a narrow tendon is called a **radiated** or **triangular** muscle (temporalis, anconeus, latissimus dorsi). Muscles with long parallel fibers (sartorius) have a greater range of motion (total distance pulled) than those with short fibers. Penniform muscles, with their many short fibers, have great power but a small range of motion.

Tendons are white, extremely strong nonelastic cords or bands that connect a fleshy muscle belly to its attachment on the skeleton. They never stretch, lengthen, or otherwise change from their original shape when pulled by their contracting muscle. They vary in thickness, shape, length, and width, and a single tendon can begin as one shape (round) and end as another (flat). Its direction may be in line with the axis of its muscle, or it may change direction in the middle of its length to head toward another point, much the way a cable curves around a pulley. **Tendinous intersections** are tendons that are embedded in a muscle belly in an oblique or perpendicular orientation relative to the length of the belly and its individual muscle fibers (rectus abdominis, semitendinosus).

An **aponeurosis** is simply a very wide, flat, sheetlike tendon. Because it is thin, it reveals the forms of the muscles that lie deep to it. When an aponeurosis is tensed by its own muscle's contraction, it can pull across and distort an underlying muscle form which it passes over (when the deeper muscle is relaxed), much like pulling a thin pillowcase across the soft pillow inside it (e.g., the aponeurosis of the latissimus dorsi covering the erector spinae). A **raphe** is a tendinous band located either within a muscle, at the junction of two muscles, or where a muscle of one side of the body meets its fellow of the opposite side (mylohyoid). It has minimal, if any, attachment to the skeleton.

Oftentimes, a change of surface form can be seen where a muscle attaches to its tendon. This can occur when both are wide and flat (latissimus dorsi) or narrow (peroneus longus). In the latter case, the part of the tendon that attaches to the muscle shows up as a depression when the surrounding tensed muscle fibers bulge.

Tendinous material sometimes expands in sheetlike fashion over the outer surface of its own muscle belly. Since this **tendinous expansion** is nonelastic, when the muscle contracts, the covered part is prevented from bulging, while the uncovered fleshy part bulges in sharp contrast. This is most clearly seen in the upper end of the gastrocnemius, which has flattened, tendon-covered areas and raised, uncovered muscular columns. It is also seen at the upper end of the long head of the triceps. This phe-

nomenon occurs frequently—yet usually more subtly—in other parts of the body.

In the forearm and lower leg, the muscle mass is located proximally and their tendons distally. The shifting of the weight of the muscle mass away from the hand and foot toward the elbow and knee respectively makes the ends of the limbs lighter and gives them greater freedom of movement. This eliminates problems of inertia caused by additional weight in starting and stopping motion.

The **deep fascia** is a dense fibrous connective tissue that penetrates and surrounds all the individual muscles and groups of muscles, forming an enveloping sheath around them. It holds the muscles in their positions, separates them functionally (with a lubricating fluid between them) so adjacent muscles can glide over one another, provides areas of attachment for other muscles, and binds neighboring muscles with similar functions into groups. The deep fascia also surrounds all the muscles of a region (limbs, body wall), forming an enclosing "stocking." In certain areas, this stocking thickens for mechanical needs, such as in the iliotibial tract, the band of Richer, and the bicipital aponeurosis. The deep fascia that passes between muscle groups and thickens into **intermuscular septa** provides additional attachment surfaces for muscles. Deep fascia and aponeuroses (or tendons) are different types of connective tissue structures, but at times may function similarly.

Retinacula are strong thick bands of deep fascia that wrap around the wrist and ankle, holding tendons in place when their muscles contract. Only occasionally visible themselves, they often influence the curvature of the tendons they constrict. The oblique portion of the inferior extensor retinaculum on the front of the ankle and the extensor retinaculum on the back of the wrist immediately distal to the radius are occasionally seen. The deep fascia on the flexor aspect of the fingers and toes forms fascial tunnels which hold the finger tendons in place.

The **superficial fascia** (tela subcutanea) is located between the skin and the deep fascia. Among the structures it contains that are of interest to artists are the fat (panniculus adiposus), the mammary glands, some of the facial muscles and the platysma, and the superficial veins.

The names of muscles are derived from their *location* (brachialis, tibialis, infraspinatus); *placement* (anterior, external, lateralis, medialis); *direction* (rectus, oblique); *action* (flexor, extensor, adductor, pronator); *shape* (teres, rhomboid, deltoid); *size* (major, minor); *structure* or number of divisions (biceps, triceps, quadriceps); and *attachments* (sternocleidomastoid, brachioradialis).

The point, line, or area to which a muscle is fastened, which may be bone, cartilage, ligaments, other muscles' surfaces, other muscles' tendons, intermuscular septa, or the deep surface of the skin, is called its **attachment.** For a given muscle, the area of attachment located on a part of the body that is mostly fixed (e.g., pelvis) is called the **origin,** while the area of attachment on a relatively more movable part (e.g., femur) is termed the **insertion.** Usually the proximal attachment is the origin and the distal attachment is the insertion. However, the terms origin and insertion are only a traditional convention used to describe attachment areas based on the more *usual* fixed and movable areas of the body. For example, when one does a chin-up, the usually fixed attachment of the latissimus dorsi on the lower back becomes the more movable of the two (the origin is lifted). It is best to think of a muscle as being attached between two sites, and when the muscle contracts and produces movement, *these points are simply brought closer together.*

Function

Muscles produce motion only by *pulling* (contracting). When a muscle contracts, it brings its two ends closer together, and *the muscle belly gets shorter and thicker.* The distal end of the belly (where it attaches to its tendon, if present) moves toward its origin. This is most noticeable on the surface when muscles adjacent to it are not moving or are moving in the opposite direction.

Muscles act across movable joints. A **one-joint muscle** crosses a single joint and produces motion in that joint (the brachialis crossing the front of the elbow joint flexes the forearm). A **two-joint** or **multi-joint muscle** crosses two or more joints and produces motion in all those joints (the semitendinosus extends the hip joint and flexes the knee; the latissimus dorsi passes from the spine and pelvis to the upper arm and moves the humerus and shoulder girdle). A multi-joint muscle will move only one of the joints it crosses if the other joint(s) has been fixed by other muscles. Different parts of the same muscle can have completely different actions (the anterior part of the deltoid flexes the upper arm, the posterior part extends it; the various portions of the trapezius move the scapula in different directions).

Two or more muscles performing the same action combine functionally and visually into a "muscle group" (quadriceps of the thigh; hamstrings of the thigh; flexors of the elbow). Adjacent muscle groups that have different actions are often separated by a furrow or a groove (in the thigh, the adductor group is separated visually from the quadriceps group, but not from the hamstring group).

A contraction of a muscle that produces a change in the length of that muscle is called an **isotonic contraction.** When the muscle shortens, **concentric contraction,** or *active shortening*, takes place. When the muscle works to control the descent of a part of the body by lengthening in a controlled release ("decontraction"), such as when the erector spinae gets longer by slowly lowering the trunk toward the pull of gravity, **eccentric contraction,** or *active lengthening*, is occurring. In this case, the rectus abdominis (the trunk flexor) passively shortens without working, and is going through *adaptive shortening* (adaptive "contraction"). When a muscle is passively stretched, as is the rectus abdominis when the thorax is then straightened up from the flexed position, it goes through *adaptive lengthening*.

Isometric contraction occurs when a muscle tenses (or contracts) and no motion or change of muscle length takes place. If a muscle is contracted isotonically or isometrically, its belly and tendon usually become increasingly more defined as the muscle is more powerfully contracted (by innervating more and more muscle fibers). The increase in definition develops as the tensed muscle (and tendon) tightens between its sites of attachment. When relaxed, muscles are soft and less defined; they may hang loosely because of gravity's pull.

A **prime mover,** or **agonist,** is the principle muscle (or muscle group) that acts on one side of a joint to bring about movement. It is usually matched on the other side of the joint, by a muscle (or muscle group), its **antagonist,** which has the opposite action (the biceps brachii and brachialis—forearm flexors—and the triceps—forearm extensor—are antagonists). When a prime mover contracts concentrically, its antagonist relaxes and passively lengthens. When gravity acts as a prime mover, its muscular antagonist will act in eccentric contraction (the deltoid "decontracts" to lower the arm against the pull of gravity).

Synergists are muscles that contract *at the same time* as the prime mover; they can function in the following ways:

1. They prevent unwanted movement that may be produced secondarily by the prime mover (when the finger flexors are used to flex just the fingers, the extensors of the wrist must act as synergists on the opposite side of the joint to prevent flexion of the wrist by continued action of the finger flexors). These synergists contract isometrically.
2. They directly assist the prime mover on the same side of the joint (the finger flexors act as synergists when they assist the wrist flexors in flexing the wrist). These synergists contract concentrically.
3. They work as **fixators** to freeze motion of one joint, enabling another joint to function without unwanted motion. In this case, the synergists are the muscles located on two or more sides of the frozen joint which contract simultaneously to stabilize that joint (fixators lock the elbow in position so the hand can move at the wrist joint). Usually a proximal joint is fixed so a distal joint can move. These synergists contract isometrically.

Because of the complex workings of the musculoskeletal system, when observing the figure in action, be aware of *all* of the muscles working on different sides of the various joints, not only the prime movers. In the body, *single muscles almost never act alone!* For example, when abducting the thumb, the flexor carpi ulnaris and extensor carpi ulnaris can be felt contracting on the opposite side of the wrist to prevent radial deviation of the wrist; when standing erect, the erector spinae of the back is flaccid, but when the arm is flexed upward in front of the body, moving the center of gravity forward, it contracts to hold the thorax erect.

When a multi-joint muscle has actively contracted to the shortest length it is physiologically able to reach and unable to contract further, but the joints it acts on are still capable of continuing their motion, the muscle is said to be **actively insufficient.** It cannot simultaneously complete the range of motion of all the joints it crosses. For example, when in the standing position, the hamstring muscles on the back of the thigh become actively insufficient after they have flexed the knee as far as they can. In this case, the knee can only be flexed further by external forces, such as when the hand is used to pull the ankle toward the pelvis.

Passive insufficiency refers to a "taut" multi-joint muscle that has been stretched to its longest limit, but the joints it crosses are still capable of further continuing their motion. In this situation, the muscle is hard and is at its narrowest width because it has been stretched to its limit. This limit can be increased with stretching exercises. For example, the hamstring muscles on the back of the thigh become passively insufficient when they prevent one from touching the toes with the fingertips while the knees are kept straight. In this case, the **ligamentous action** of the hamstrings prevents the hip joint from fully flexing. As soon as the knees are bent, slackening the hamstrings, the pelvis rotates forward and the fingers can then touch the toes.

An example of both types of insufficiencies taking place simultaneously are seen in the finger flexors and extensors. The finger flexors are most effective in making a clenched fist when the wrist is straight or slightly extended. It is

usually not possible to make a fist when the wrist is fully flexed, because the finger flexors are too short to contract further (active insufficiency) and the finger extensors are fully stretched (passive insufficiency), preventing the fingers from flexing fully.

In analyzing muscular activity, it is important to think in terms of the combined actions of all the muscles in a given area—some work individually, others work as groups; some stabilize one region of the body while others create motion in another region; some begin an action while other muscles complete it; some oppose the pull of gravity. During complex actions, note the *sequence* of the contraction and relaxation of the numerous muscles that are functioning. Observe the action, visualize the skeleton deep in the body and what changes are taking place at its joints, and then determine which muscles are working in order to perform that action. For further information on function, refer to the most recent updated medical, physiology, kinesiology, and physical therapy texts.

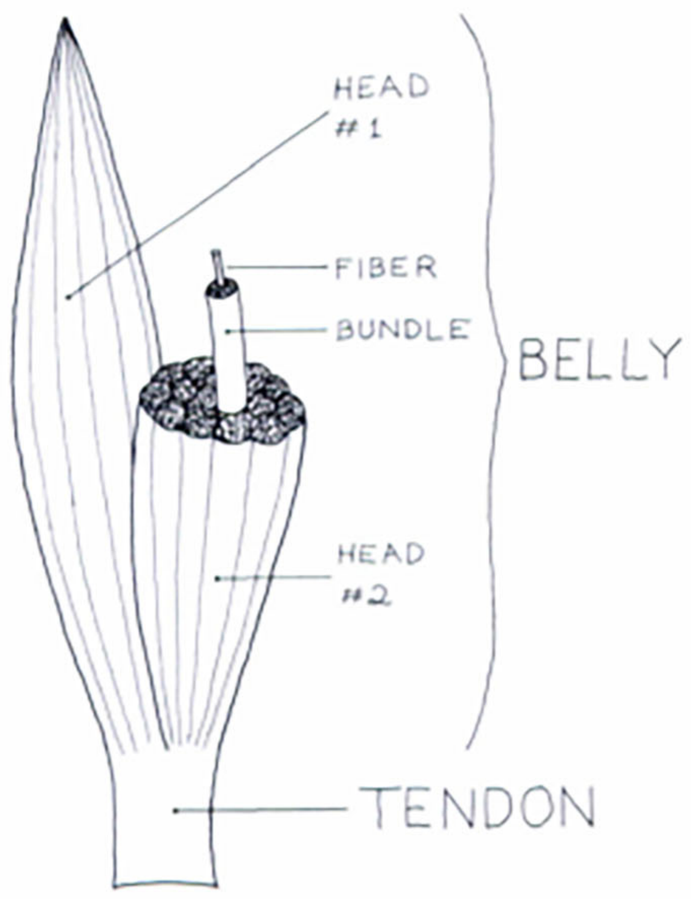
Form

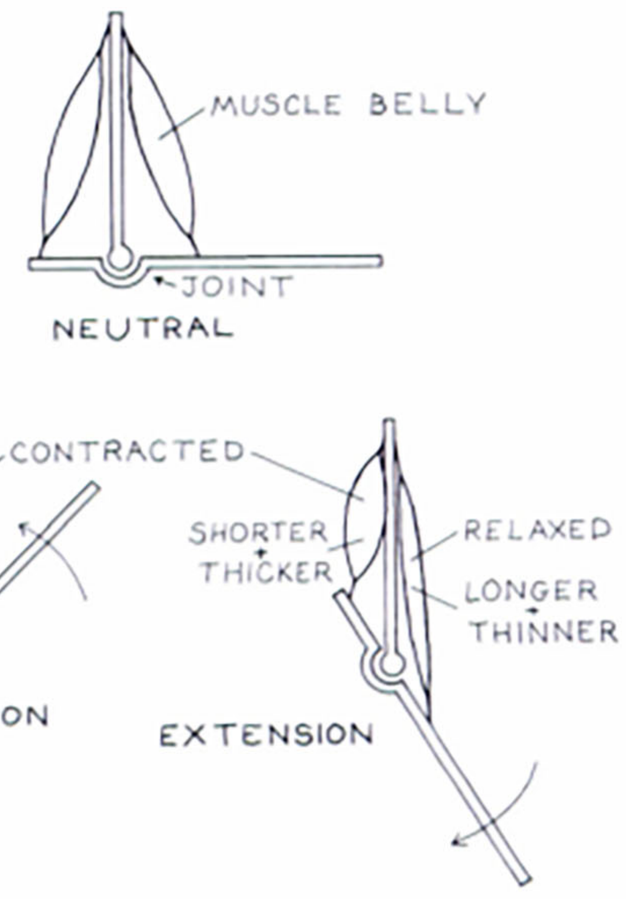
The muscles of the body are independent convex forms, and when placed side by side and one on top of the other to make up the figure, they structure the figure into a series of adjacent, bulging, convex forms which are covered by the skin. An appreciation of the *fullness of these convexities* will produce artwork with vitality and a feeling of energetic inner life radiating from the center outward. True concavities show up only rarely in the body, and one must be careful not to mistake a series of convexities for a concavity. Know the attachments of muscles, because that is where their *form* begins and ends. *Know the basic individual shapes of each muscle.* Think of the form of a muscle as a swollen axis passing between the centers of its areas of attachment.

Beware of illustrations that simply diagram the surface muscles' outlines without giving indication of the deeper structures that may actually be creating the forms we see (very little of the form of the latissimus dorsi is directly seen; it is the forms of the deeper structures—erector spinae, serratus anterior, teres major, and rib cage—that create surface form). Keep in mind that the form of one muscle can blend with the form of another muscle or with fat pads, that the shapes of muscles are sometimes affected by overlying fascia, that muscles appear shorter and thicker when contracted and longer and thinner when stretched, and that they become more defined when they are contracted. In other words, the same muscle will appear differently in different actions and poses.

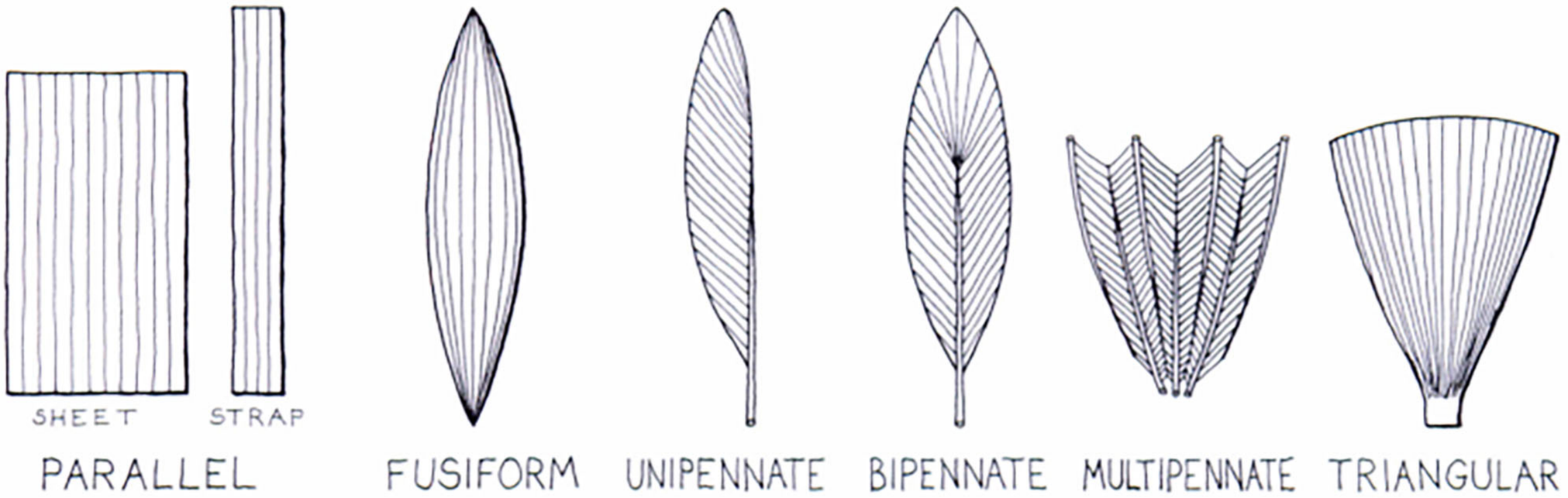
The artist must understand all the anatomical components that create human surface form, and when studying the living model, be able to mentally impose these structures diagrammatically on the model. For while everything is there, most of it is usually concealed to the untrained eye. It becomes the artist's job to analyze, select, and then create.

Note: In the following illustrations, muscle attachments on the skeleton are indicated by solid red areas, while nonbony attachment areas are usually indicated by red cross-hatching. They are labeled O for origin and I for insertion. A curved arrow indicates that an attachment is hidden from view. *All illustrations are of the right side of the body.*

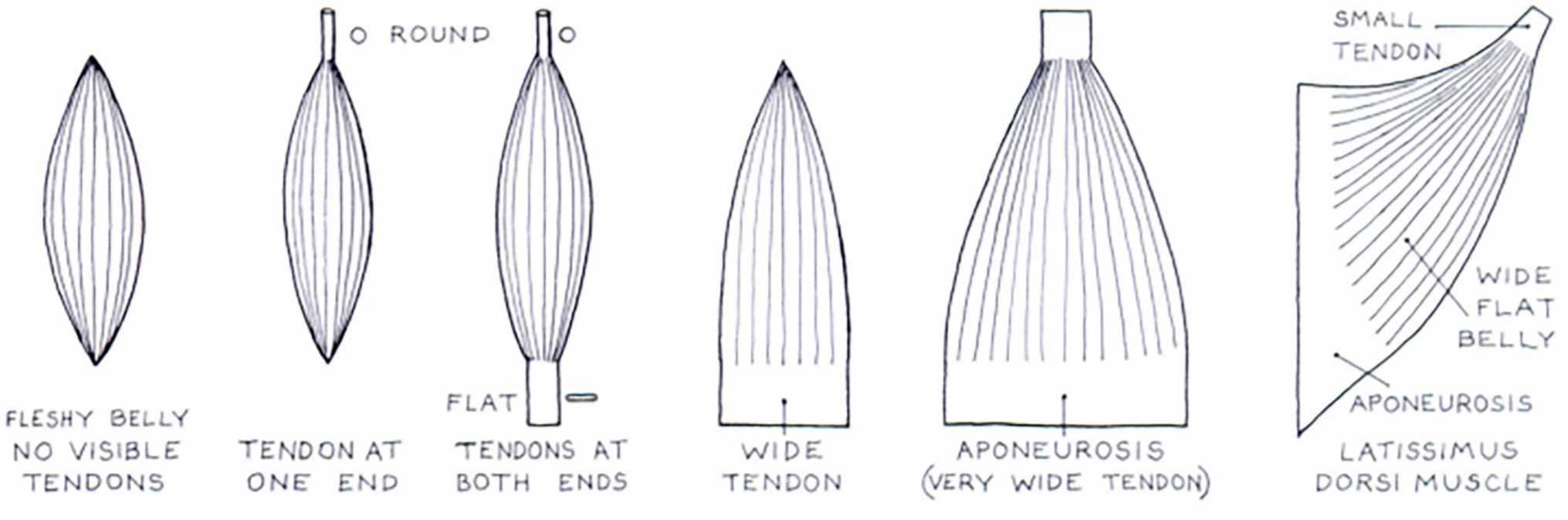




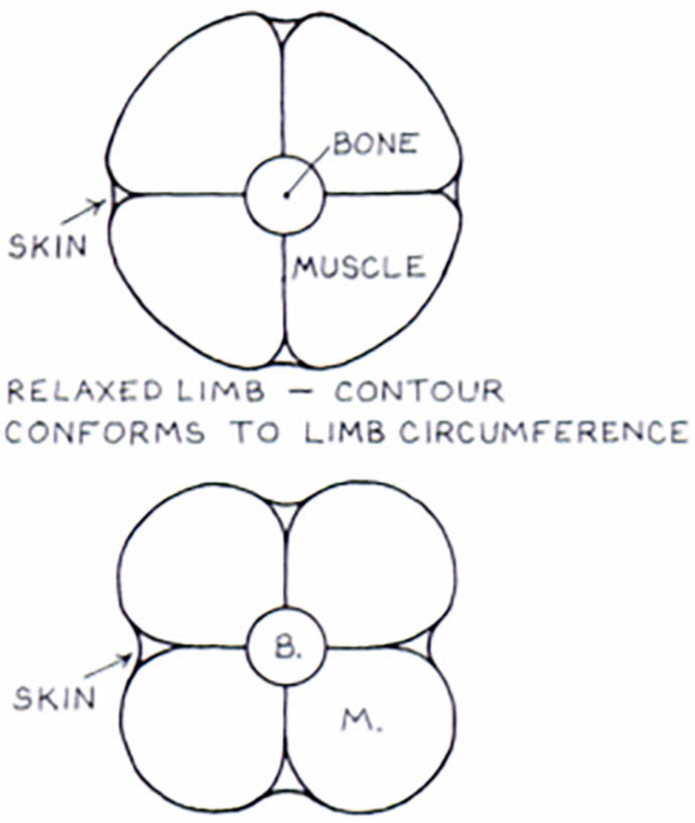
MUSCLE TYPES



BELLY—TENDON RELATIONSHIPS



STYLIZED LIMB CROSS SECTION



Relaxed limb

Tensed limb

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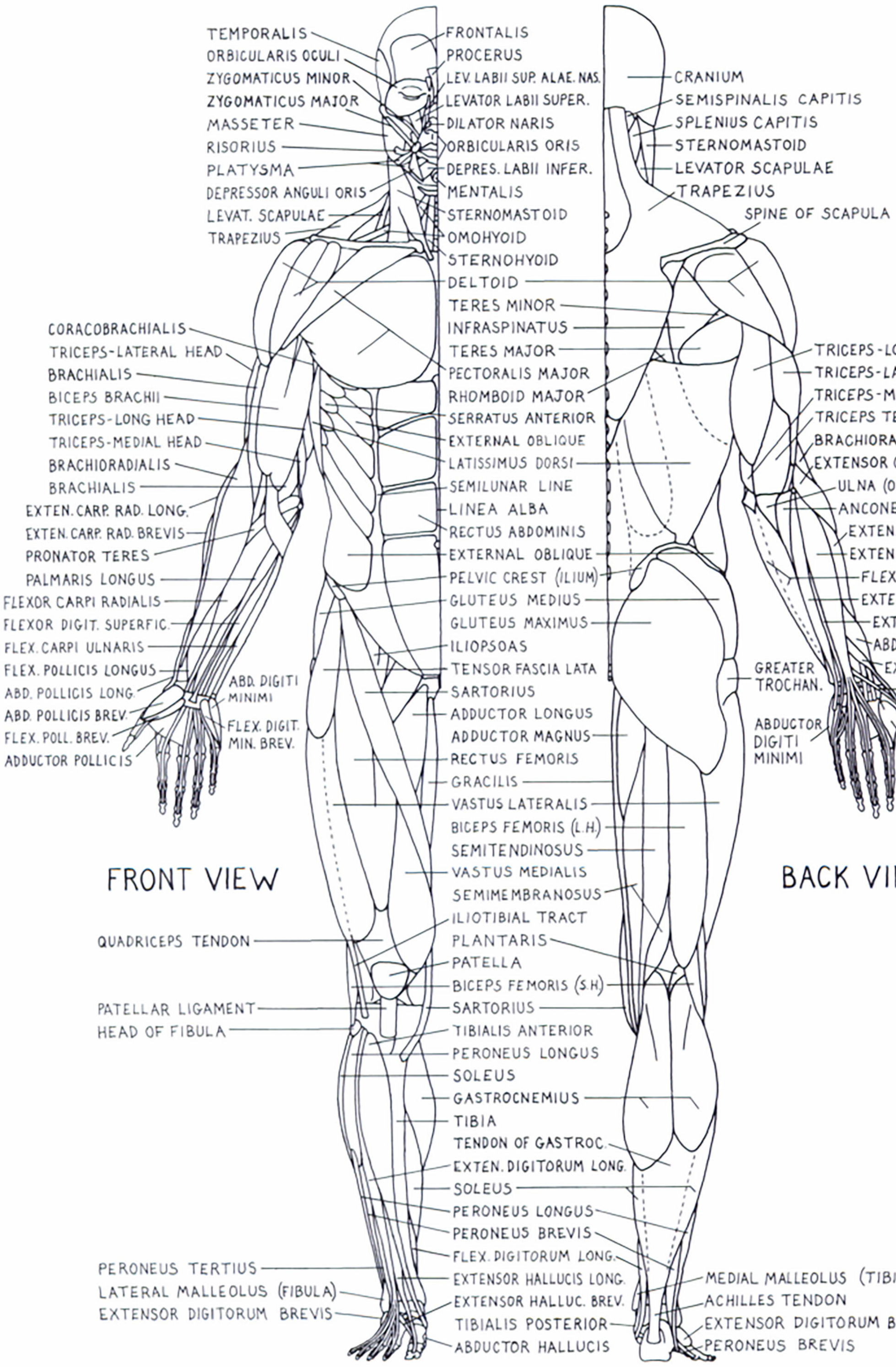

TEMPORALIS
ORBICULARIS OCULI
ZYGOMATICUS MINOR
ZYGOMATICUS MAJOR
MASSETER
RISORIUS
PLATYSMA
DEPRESSOR ANGULI ORIS
LEVAT. SCAPULAE
TRAPEZIUS
CORACOBRACHIALIS
TRICEPS-LATERAL HEAD
BRACHIALIS
BICEPS BRACHII
TRICEPS-LONG HEAD
TRICEPS-MEDIAL HEAD
BRACHIORADIALIS
BRACHIALIS
EXTEN. CARP. RAD. LONG.
EXTEN. CARP. RAD. BREVIS
PRONATOR TERES
PALMARIS LONGUS
FLEXOR CARPI RADIALIS
FLEXOR DIGIT. SUPERFIC.
FLEX. CARPI ULNARIS
FLEX. POLLICIS LONGUS
ABD. POLLICIS LONG.
ABD. POLLICIS BREV.
FLEX. POLL. BREV.
ADDUCTOR POLLICIS
ABD. DIGITI MINIMI
FLEX. DIGIT. MIN. BREV.
FRONTALIS
PROCERUS
LEV. LABII SUP. ALAE. NAS.
LEVATOR LABII SUPER.
DILATOR NARIS
ORBICULARIS ORIS
DEPRES. LABII INFER.
MENTALIS
STERNOMASTOID
OMOHYOID
STERNOHYOID
DELTOID
TERES MINOR
INFRASPINATUS
TERES MAJOR
PECTORALIS MAJOR
RHOMBOID MAJOR
SERRATUS ANTERIOR
EXTERNAL OBLIQUE
LATISSIMUS DORSI
SEMILUNAR LINE
LINEA ALBA
RECTUS ABDOMINIS
EXTERNAL OBLIQUE
PELVIC CREST (ILIUM)
GLUTEUS MEDIUS
GLUTEUS MAXIMUS
ILIOPSOAS
TENSOR FASCIA LATA
SARTORIUS
ADDUCTOR LONGUS
ADDUCTOR MAGNUS
RECTUS FEMORIS
GRACILIS
VASTUS LATERALIS
BICEPS FEMORIS (L.H.)
SEMITENDINOSUS
VASTUS MEDIALIS
SEMIMEMBRANOSUS
ILIOTIBIAL TRACT
PLANTARIS
PATELLA
BICEPS FEMORIS (S.H.)
SARTORIUS
TIBIALIS ANTERIOR
PERONEUS LONGUS
SOLEUS
GASTROCNEMIUS
TIBIA
TENDON OF GASTROC.
EXTEN. DIGITORUM LONG.
SOLEUS
PERONEUS LONGUS
PERONEUS BREVIS
FLEX. DIGITORUM LONG.
EXTENSOR HALLUCIS LONG.
EXTENSOR HALLUC. BREV.
TIBIALIS POSTERIOR
ABDUCTOR HALLUCIS
QUADRICEPS TENDON
PATELLAR LIGAMENT
HEAD OF FIBULA
PERONEUS TERTIUS
LATERAL MALLEOLUS (FIBULA)
EXTENSOR DIGITORUM BREVIS
FRONT VIEW
CRANIUM
SEMISPINALIS CAPITIS
SPLENIUS CAPITIS
STERNOMASTOID
LEVATOR SCAPULAE
TRAPEZIUS
SPINE OF SCAPULA
TRICEPS-LONG HEAD
TRICEPS-LATERAL HEAD
TRICEPS-MEDIAL HEAD
TRICEPS TENDON
BRACHIORADIALIS
EXTENSOR CARPI RADIALIS LONG.
ULNA (OLECRANON)
ANCONEUS
EXTEN. CARPI RADIALIS BREV.
EXTENSOR DIGITORUM
FLEXOR CARPI ULNARIS
EXTENSOR CARPI ULNARIS
EXTENSOR DIGITI MINIMI
ABDUCTOR POLLICIS LONG.
EXTEN. POLLICIS BREVIS
EXTEN. POLL. LONG.
GREATER TROCHAN.
ABDUCTOR DIGITI MINIMI
FIRST DORSAL INTEROSSEOUS
MEDIAL MALLEOLUS (TIBIA)
ACHILLES TENDON
EXTENSOR DIGITORUM BREVIS
PERONEUS BREVIS
BACK VIEW

Facial Muscles

The **facial muscles,** or **muscles of facial expression,** for the most part originate from bone and insert into muscle fibers of other facial muscles. They infrequently arise from fascia and only occasionally insert into the skin. They are used to control the facial apertures. After a facial muscle has contracted, the facial tissue is returned to its original position by the contracted muscle's antagonist and/or the resiliency of the skin and facial fat.

The facial muscles do not create surface form as directly as do the skeletal muscles. They are thin, much more delicate, and usually concealed by facial fat. However, in the mouth area bordered by the nasolabial furrows and mentolabial sulcus, where the facial fat is very thin, they do directly create surface form.

The visible forms on the face are created by several factors—skin, fatty tissue, the underlying skull, cartilage, the eyeballs, and some muscles. When the facial muscles contract, they change shape, but they also alter and move the shapes of the fatty forms, skin, and other facial muscles. They also create skin wrinkles, furrows, ridges, and bulges, usually perpendicular to the direction of the muscle fibers. All these changes create the various facial expressions.

The mouth region receives the most muscles; therefore, it is the most mobile part of the face. Both the upper and lower lips can be pulled open, exposing the teeth. This is accomplished by a number of individual muscles, located above and below the lips, contracting simultaneously. When acting together, these muscles are collectively termed the **labial tractors.** The labial tractors surround and insert into the bulk of the orbicularis oris (the mouth muscle), passing over and through its mass. Besides retracting the lips, they also assist in everting them by lifting and curling them outward.

The **upper labial tractor,** which raises the upper lip, is made up of the levator labii superioris alaeque nasi, levator labii superioris, zygomaticus minor, and malaris.

The **lower labial tractor** consists of the depressor labii inferioris and the labial portion of the platysma. The individual muscles of the labial tractors have their own very different, specific actions and effects when not contracting in unison.

The facial muscles also work in conjunction with the skeletal muscles of mastication (temporalis, masseter, digastric, pterygoids, etc.) for speaking, breathing, chewing, and creating facial expressions. The muscles of mastication move the lower jaw—opening, closing, and clenching it, moving it side to side, and protracting and retracting it.

Facial Structures

Many muscle fibers inserting into a small area of skin will produce a depressed line or small dimples on the surface when they contract.

The major line or skin furrow of the face is the **nasolabial furrow.** It passes from the top of the wing of the nose, downward and outward, to a point lateral to, and at a level slightly below, the outer corner of the mouth. It varies from being deeply incised to faintly inscribed and has multiple curvatures. This furrow is created by two factors: the upper labial tractor inserting into the deep aspect of the skin of the furrow and the edge of the cheek fat pad meeting the nonfatty upper lip area. The furrow is deepened when the bulk of the muscular upper lip area is pulled *under* the cheek fat (e.g., during smiling).

The **infraorbital furrow** is an oblique curved line which passes from a point just medial to the inner corner of the eye downward and outward over the front of the cheekbone. It forms the upper boundary of the cheek fat pad. The **lower eyelid furrow** is the skin furrow at the lower boundary of the lower eyelid where it meets the top of the cheek, or what would be the top of the bag of the eye. When the cheek is raised, several skin wrinkles may develop in the area between the lower eyelid furrow and the infraorbital furrow.

The **eye cover fold** is the flap of skin located below the lateral two-thirds of the eyebrow. It overlaps and partly conceals the upper eyelid when the eyebrow is in its relaxed position. Its shape is that of a bulged, elongated triangle whose apex is directed medially. When the eyebrow is raised, the form of the eye cover fold disappears as it is lifted and stretched.

The **glabella** is the small midline depression at the lower end of the forehead, between the superciliary arches (brow ridges), usually located between the medial ends of the eyebrows. It lies just above the root of the nose. The **root of the nose** is the sharp angle where the top of the nose meets the bottom of the glabella; it is located approximately at the level of the edge of the upper eyelid when the eye is open. The **bridge of the nose** is the upper bony portion of the front edge of the nose, formed by the two nasal bones.

The **philtrum** is the vertical, ovoid, midline depression in the upper lip, located between the base of the nose and the red part of the upper lip. The **mouth angle furrow** is a short oblique furrow descending downward and outward from the angle of the mouth. Another regularly occurring skin fold is the **mentolabial sulcus.** It is a short horizontal fold or furrow located where the top of the chin meets the bulk of the

lower lip area. The **chin boss** is the fleshy prominence of the chin. It is located on the front of the chin, not on its lower edge.

The facial fat in the young adult is basically restricted to one major fat pad on each side of the face, appropriately called the **cheek fat pad** or the **infraorbital triangle.** It sits on the front of the face, bordered by the infraorbital furrow superiorly, the nasolabial furrow inferiorly, and the nose medially. It blends into the side of the jaw laterally. The rest of the face has a layer of fat of variable thickness deposited over its surface.

As the facial muscles contract, various **skin wrinkles** form at the *edges* and *centers* of the fat pads (e.g., cheek fat) or across thin skin areas (the forehead). They usually develop perpendicular to the pull of the contracting muscle. These wrinkles are formed in much the same way that a curtain gathers into numerous wrinkles and pleats when pulled.

Of great importance, and often overlooked, is the muscular mass immediately lateral to the angle of the mouth. It has a number of names ("modiolus," meaning hub in Latin; "knoten," meaning knot in German); here it will be called the **node.** It receives the inserting fibers of several facial muscles—zygomaticus major, levator anguli oris, depressor anguli oris, buccinator, orbicularis oris (all four portions), incisivus labii superioris and inferioris, risorius, and the nodular portion of the platysma—and *is thus formed by fibers of these muscles.* It is not a separate structure, but a central point of intersection, convergence, and interweaving of facial muscle fibers. The most important function of the node is to serve as a movable point of muscle attachment for the orbicularis oris. The muscles inserting into the node first move it to various positions and then stabilize it. The lateral ends of the orbicularis oris are anchored to the node, which allows the orbicularis to contract and change shape as required.

The node can be seen on the surface as an oblique, elongated oval relief. Its upper end is the most conspicuous part, appearing as a relief form on the mass of the upper lip area just above the angle of the mouth. The medial edge of the node meets (and may cover) the extreme lateral end of the mouth line. The lateral portion of the node is usually covered by cheek fat. The lower end of the nasolabial furrow passes over the middle of the node or lateral to it. The node can be felt by pinching the thickened tissue just lateral to the angle of the mouth (with one finger inside the mouth).

Both the physical structure of the face (bone, fat, and muscle) and its expressions (produced by active muscle contraction) are often asymmetrical (the left side showing different forms and actions than the right side).

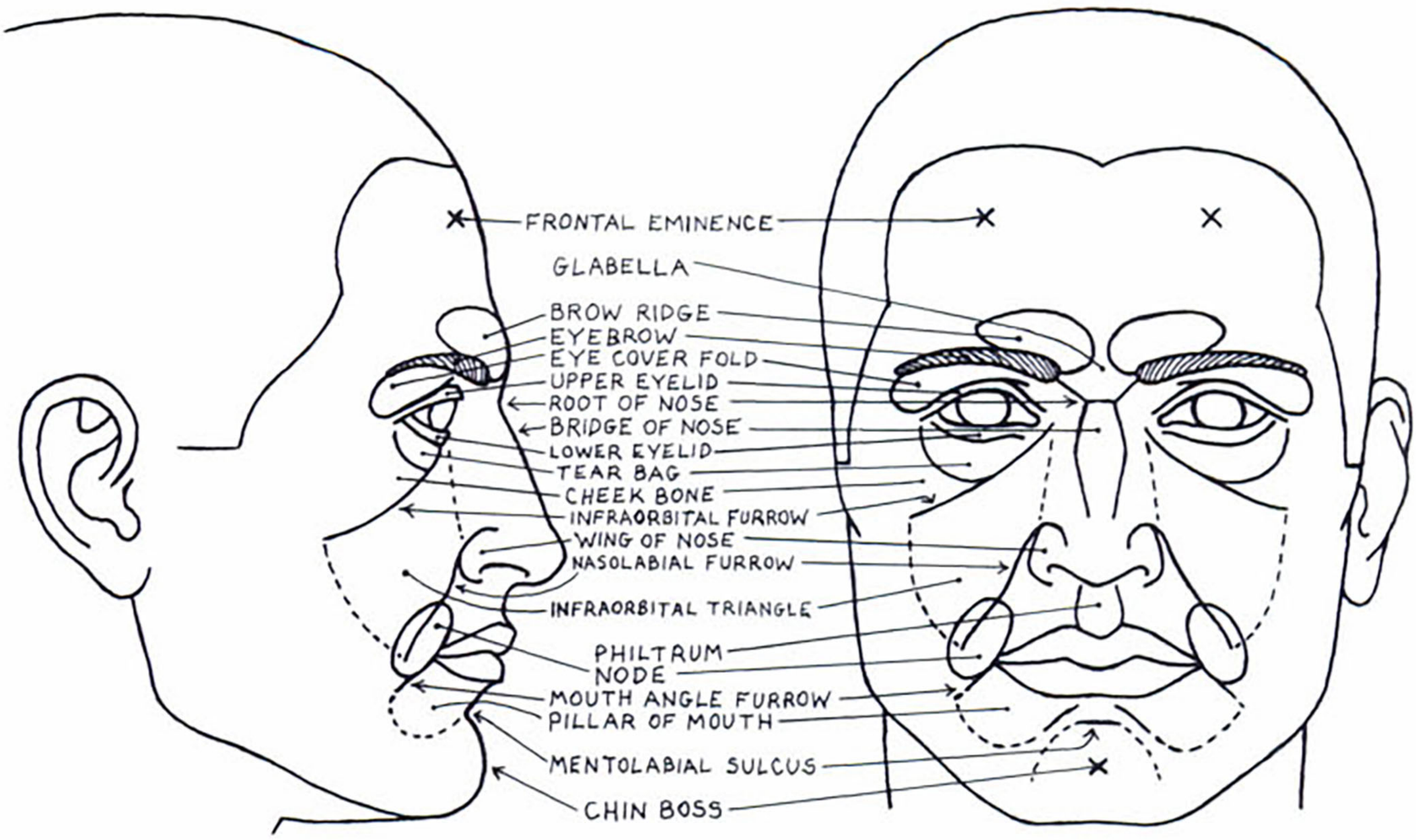
Facial Expression

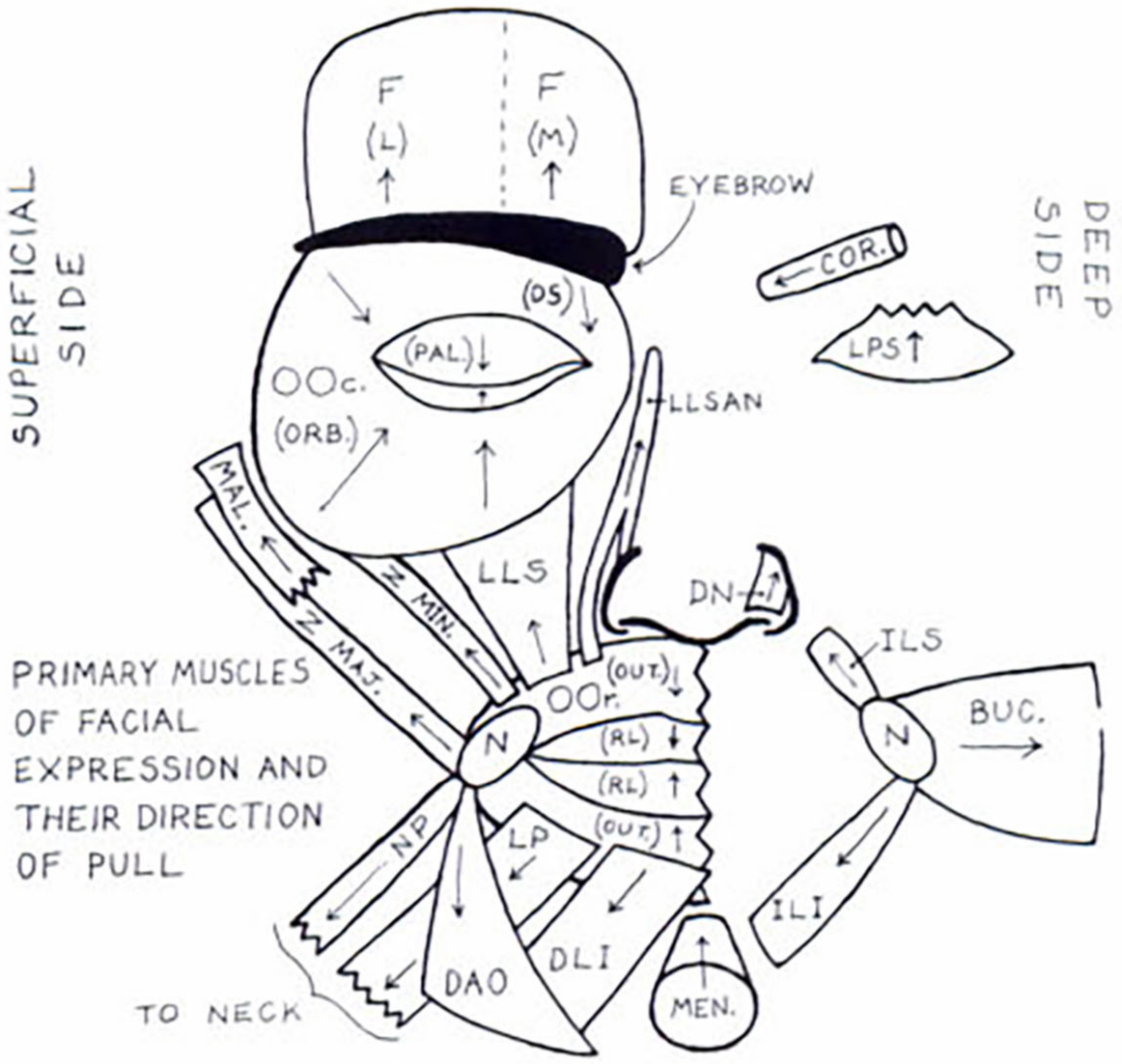
Facial expressions are created by the combination, sequence, and degree of contraction of the facial muscles and by the resulting changes to the facial forms. The facial muscles are capable of producing numerous expressions as they contract (and/or relax) in an almost infinite range of combinations. The muscular activity need not be symmetrical. The effects range from refined subtlety to extreme expressivity. Opposite expressions are often caused by antagonistic muscle groups (joy—mouth corners pulled up vs. grief—mouth corners pulled down). Overall relaxation creates the effect of tranquility or despondency, while overall contraction displays states of tension or heightened energy (passive vs. active expressions).

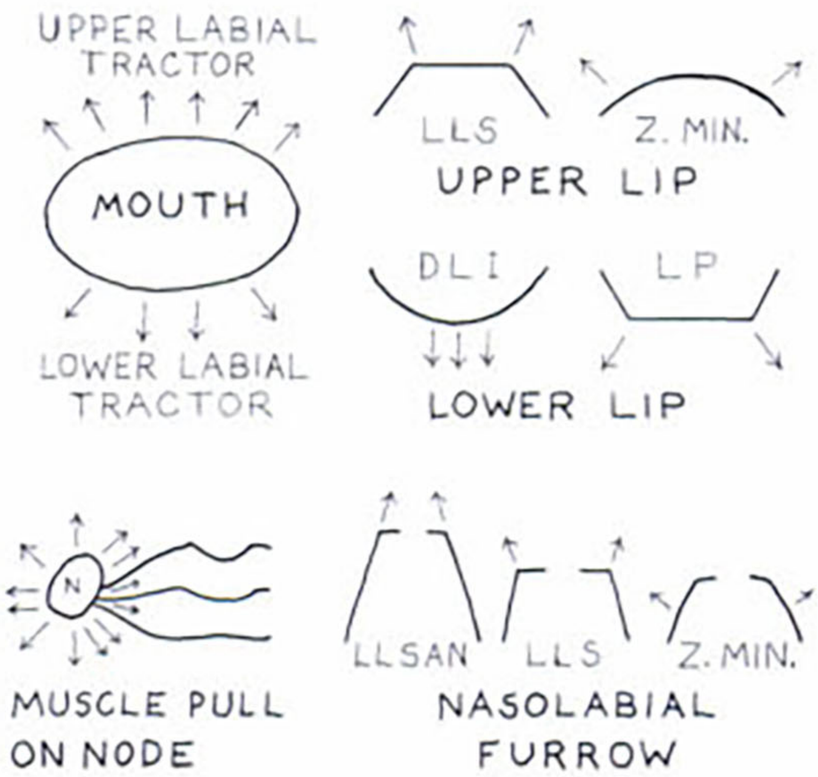
In the following individual muscle descriptions, the expressions listed are those often created or contributed to by that muscle's contraction. However, expressions usually rely on *specific muscle combinations* (see Expression of the Emotions).

When considering the structure and forms of the face, it is best to first understand the geometric volumes and planes (simple planes, then complex planes), then the shapes of the skull and facial forms, and finally the muscles of facial expression and the expressions they produce.

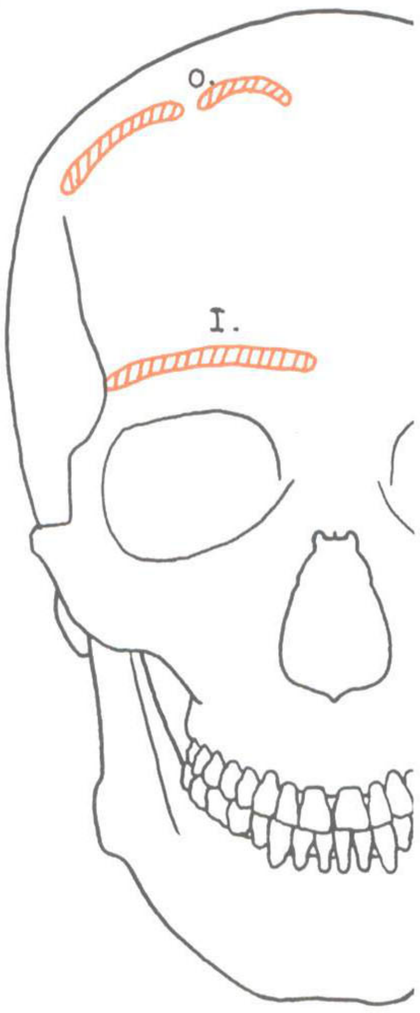
The Facial Muscles

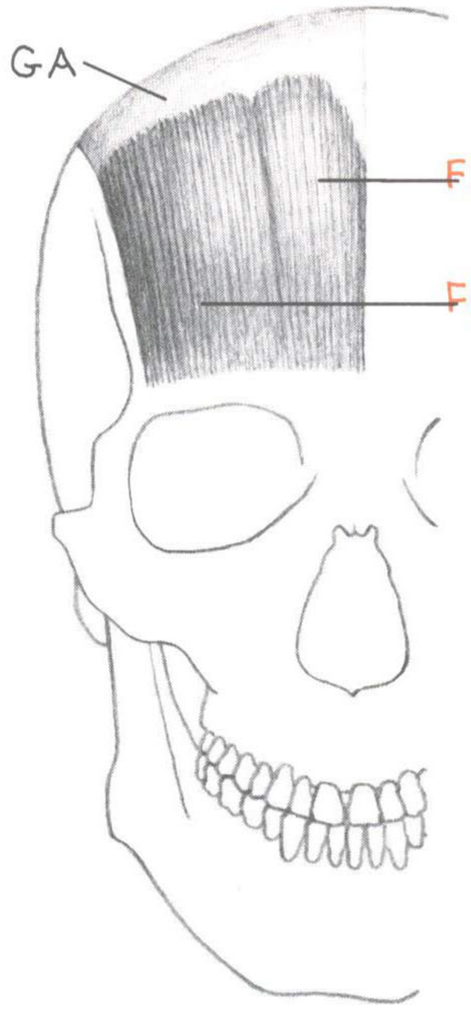


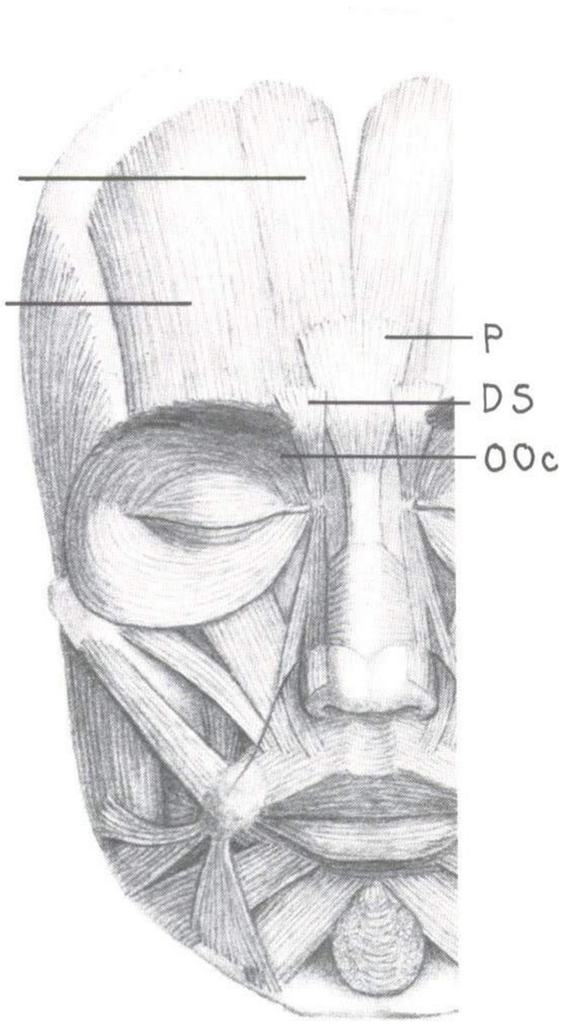


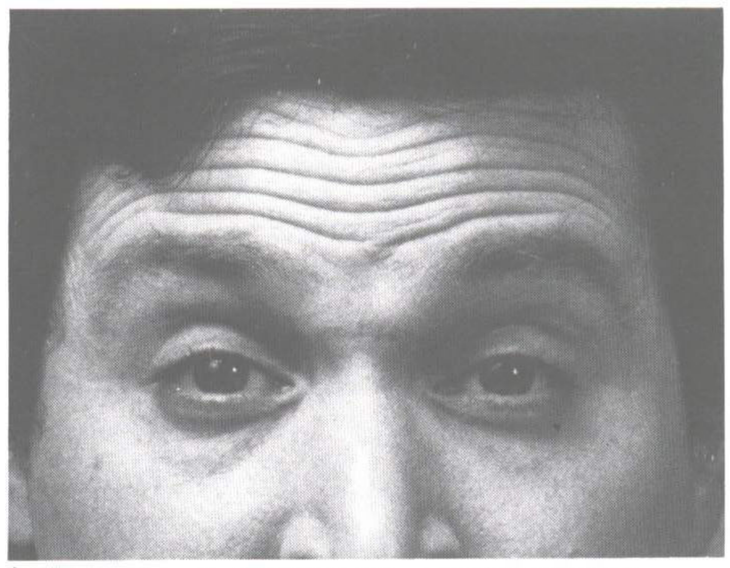


BUC *Buccinator* COR *Corrugator supercilii* DAO *Depressor anguli oris*
DLI *Depressor labii inferioris* DN *Dilator naris* DS *Depressor supercilii*
F(L) *Frontalis—lateral portion* F(M) *Frontalis—medial portion* ILI *Incisivus labii inferioris*
ILS *Incisivus labii superioris* LLS *Levator labii superioris* LLSAN *Levator labii superioris alaeque nasi*
LP *Labial platysma* LPS *Levator palpebrae superioris* MAL *Malaris* MEN *Mentalis* N *Node*
NP *Nodular platysma* OOc(ORB) *Orbicularis oculi—orbital portion*
OOc(PAL) *Orbicularis oculi—palpebral portion* OOr(OUT) *Orbicularis oris—outer portion*
OOr(RL) *Orbicularis oris—red lip portion* ZMAJ *Zygomaticus major* ZMIN *Zygomaticus minor*

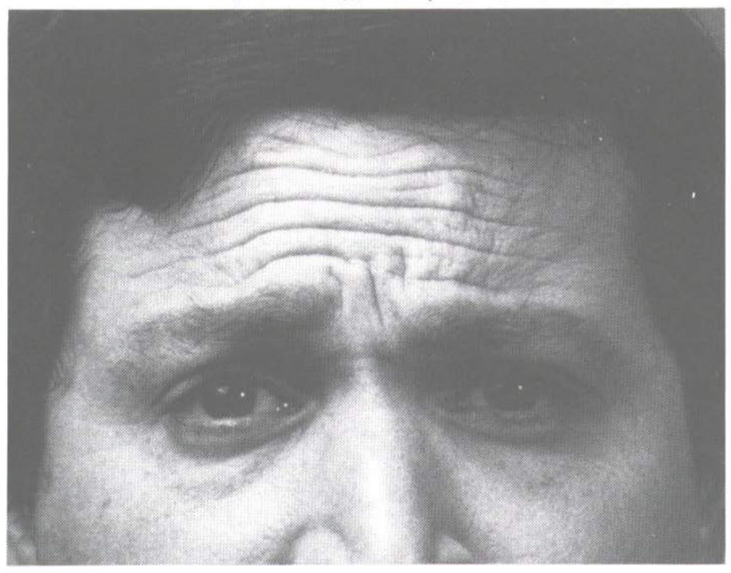




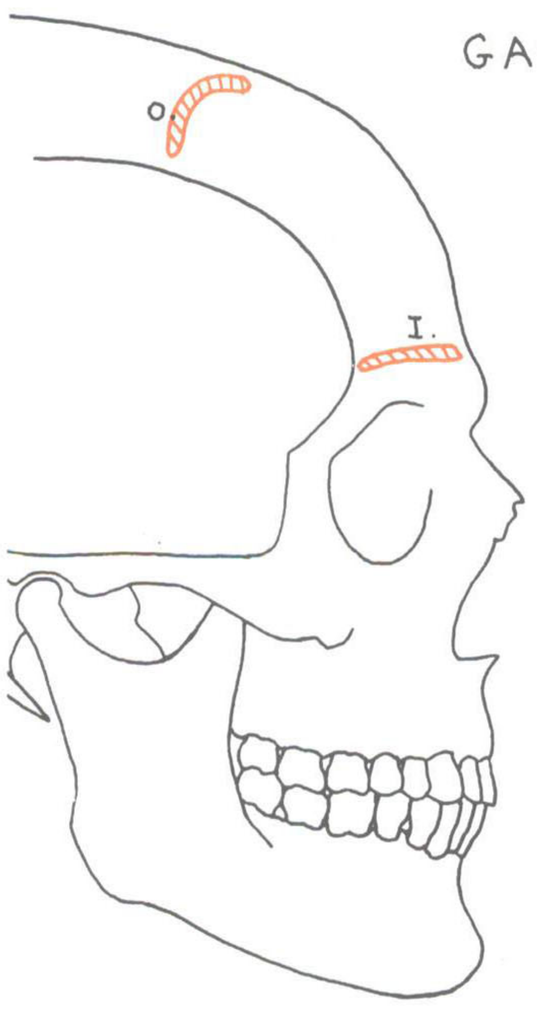


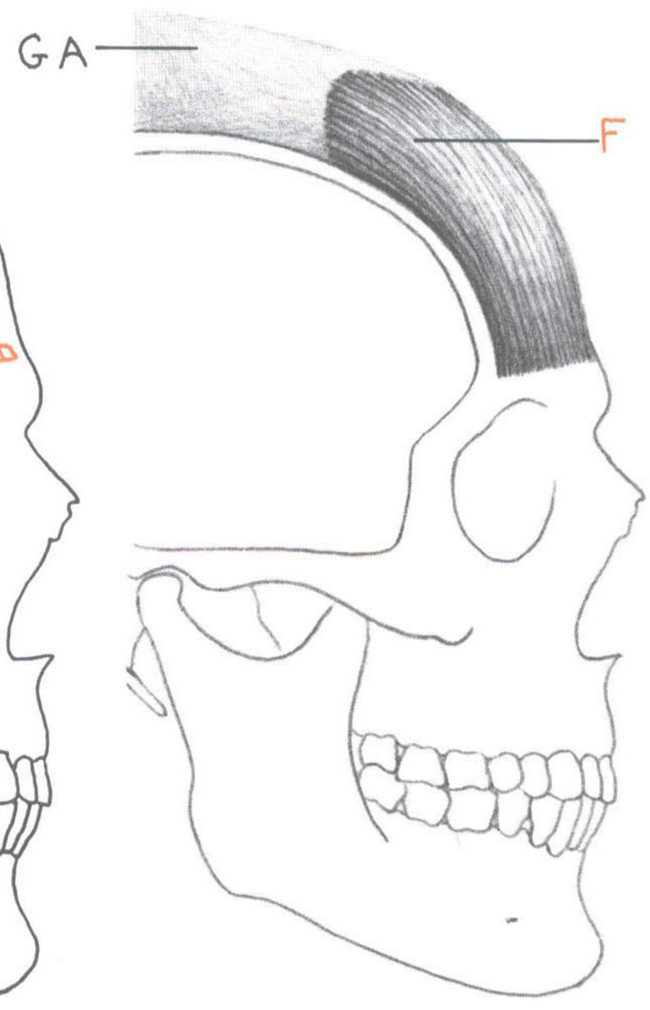


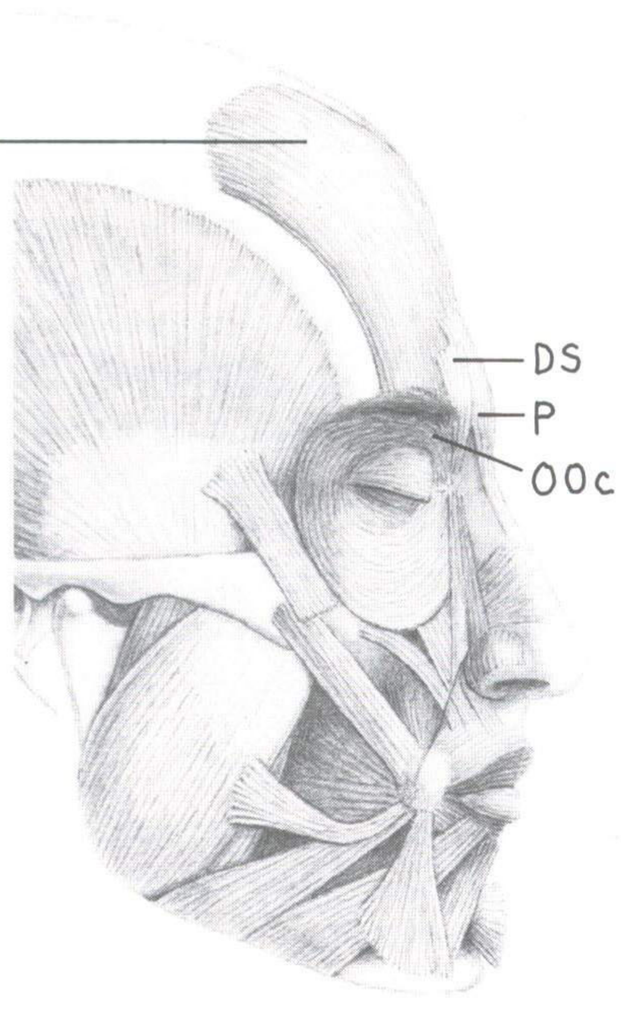
MEDIAL + LATERAL PORTIONS



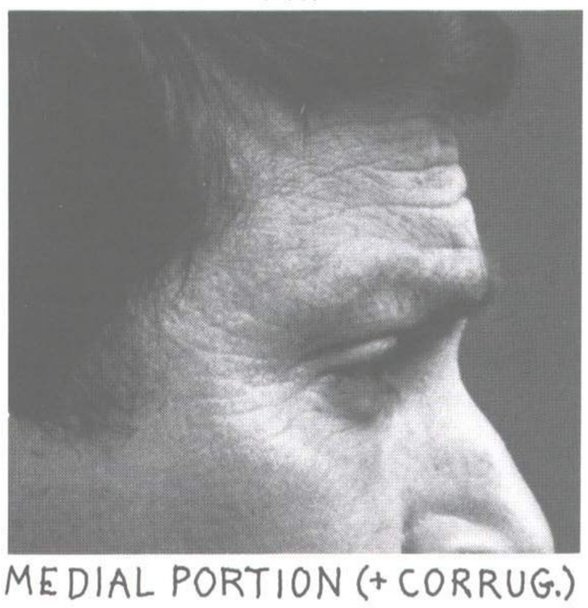
MEDIAL PORTION (+ CORRUGATOR)







MEDIAL+LATERAL PORTIONS



MEDIAL PORTION (+ CORRUG.)

DS *Depressor supercilii* **F(L)** *Frontalis—lateral portion* **F(M)** *Frontalis—medial portion*
GA *Galea aponeurotica* **OOc** *Orbicularis oculi* **P** *Procerus*

Frontalis

The **frontalis** is the anterior muscle belly of the extensive epicranius muscle.

The **epicranius muscle** consists of a broad layer of tendon (the galea aponeurotica) and thin muscle bellies; it covers the top and sides of the skull, from the brows in front to the base of the skull in back, and over to the tops of the ears.

ORIGIN The front edge of the galea aponeurotica, just posterior to the top of the forehead.

INSERTION The skin at the eyebrow and root of the nose, blending with the fibers of the procerus, orbicularis oculi, and corrugator supercilii.

ACTION *Medial and lateral portions together:* Raise the entire eyebrow, increasing its overall curvature (the central portion is pulled higher). They also pull the scalp (hairline) slightly forward as they pull on the galea aponeurotica. *Medial portion only:* Pulls up the medial end of the eyebrow. *Lateral portion only:* Pulls the middle and lateral end of the eyebrow upward, giving the eyebrow a strong curvature.

The medial portions of both sides of the face always contract together and are almost always accompanied by contraction of the corrugator supercilii (as in sadness). The lateral portion only occasionally contracts by itself, and usually in one eyebrow only.

STRUCTURE The frontalis is divisible functionally into medial and lateral parts. The two frontalis bellies of the head are in contact with each other at their lower portion, on the midline of the forehead.

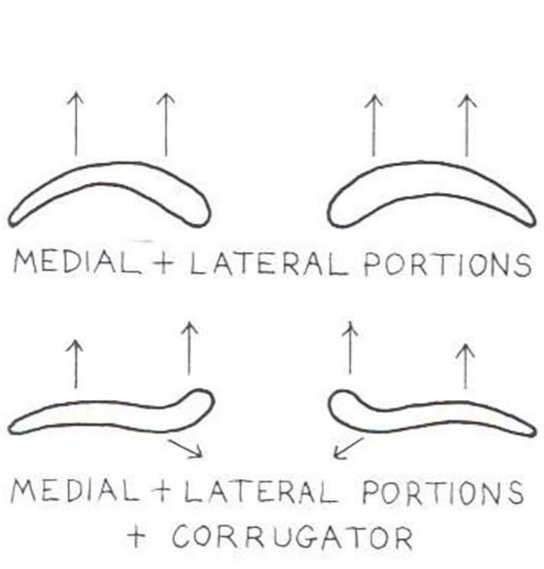
EFFECT Contraction of the frontal bellies produces horizontal wrinkles across the forehead. The wrinkles are superiorly curved above each eyebrow and dip downward on the centerline. When only the medial part of the frontal belly contracts, horizontal wrinkles form on the center of the forehead only. In this case the medial ends of the eyebrows are pulled upward. However, depending on the position (obliquity) of the eyebrows in the resting position, the medial ends may not appear to have been raised. Horizontal wrinkles on the center of the forehead are diagnostic of medial frontalis contraction. Because the corrugator typically contracts when only the medial frontalis contracts, the eyebrow develops a "kinking" near its medial end or an overall S-shaped curvature; its medial end is pulled upward by the medial frontalis, and its center is pulled downward by the corrugator. As a person ages, the forehead wrinkles do not fully disappear when the frontal bellies are relaxed.

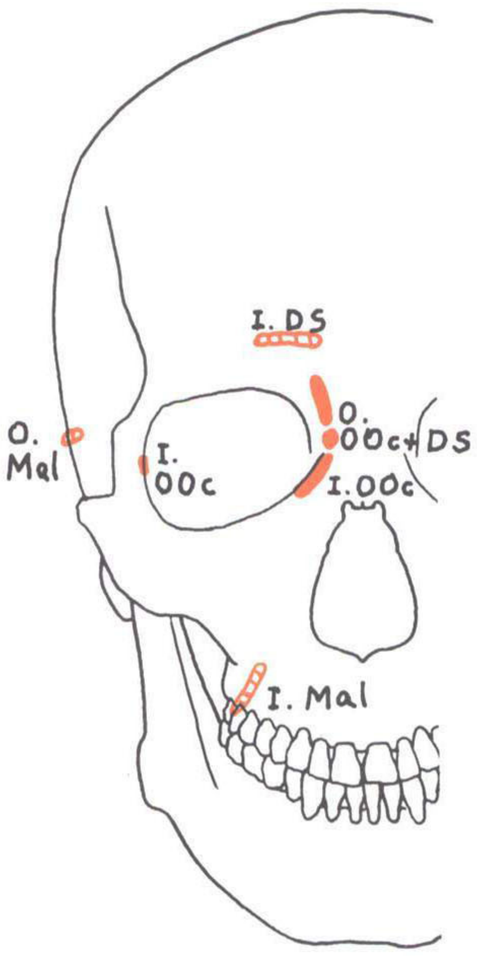
When the eyebrows are raised, the root of the nose becomes thinner and the glabella becomes smooth. Raising the eyebrows also pulls the skin between the eyebrow and upper eyelid upward, exposing more of the eyelid. The skin below the eyebrow (the eye cover fold) then loses its form (its bulging quality) and becomes stretched over the bone beneath, revealing the form of the bony orbit. The distance between the medial end of the eyebrow and the inner corner of the eye increases; this is especially noticeable when only the medial portions are contracted.

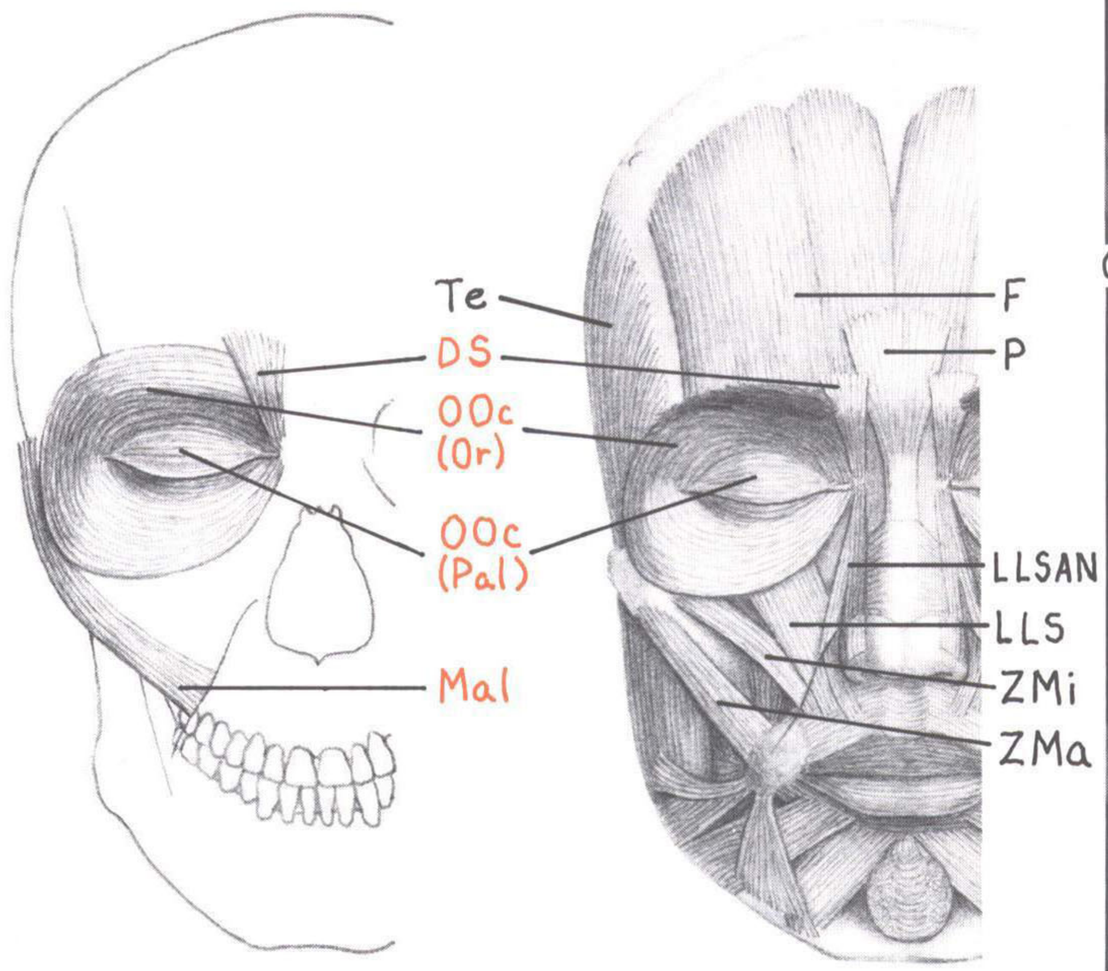
When the eyebrows are raised, the ears also rise slightly.

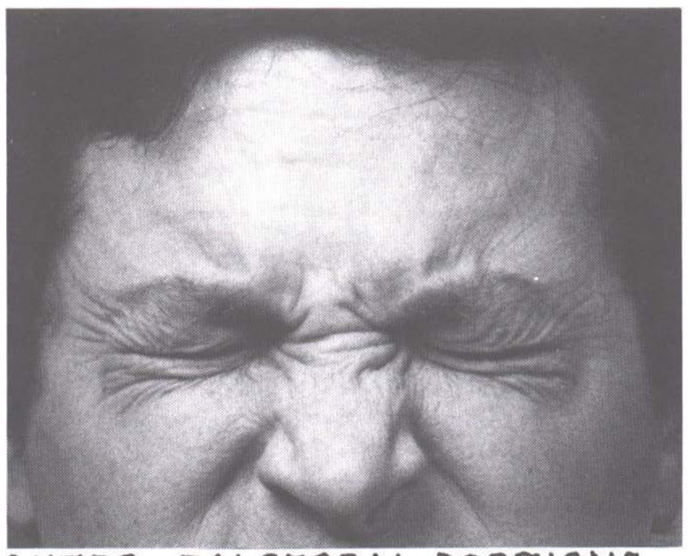
EXPRESSION *Medial and lateral portions of both sides of the face:* surprise, astonishment; fear, fright, horror; interest, attention; questioning, doubt. *Medial portions of both sides of the face* (with corrugator): sadness, grief, suffering; sometimes fear. *Medial and lateral portions of one side of the face:* inquisitiveness, skepticism. *Lateral portion of one side of the face:* sly, devious look.

Contraction of the entire frontalis is often used as a greeting signal or for conversational emphasis. This use is not an expression of emotion.









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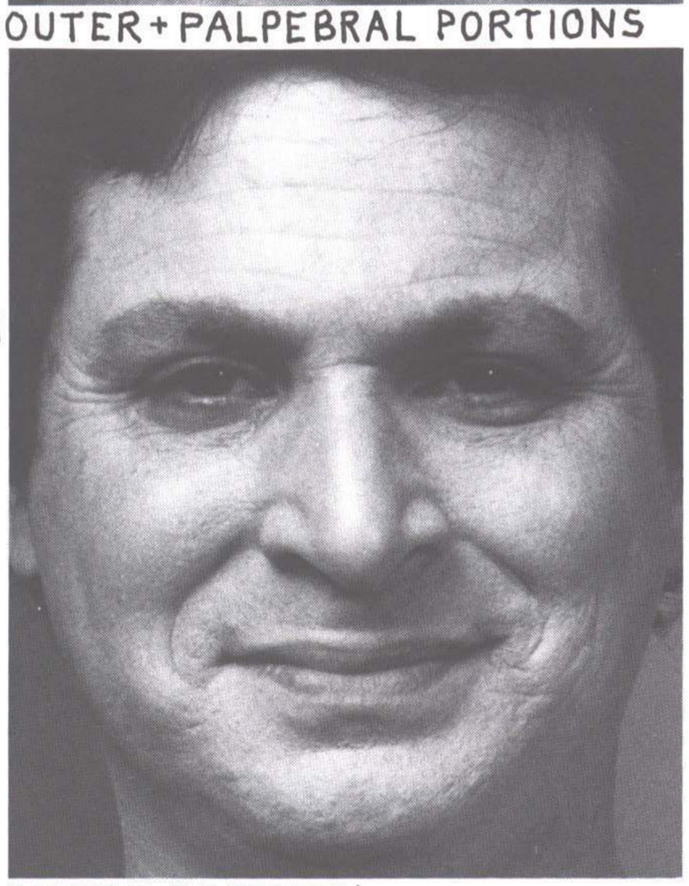

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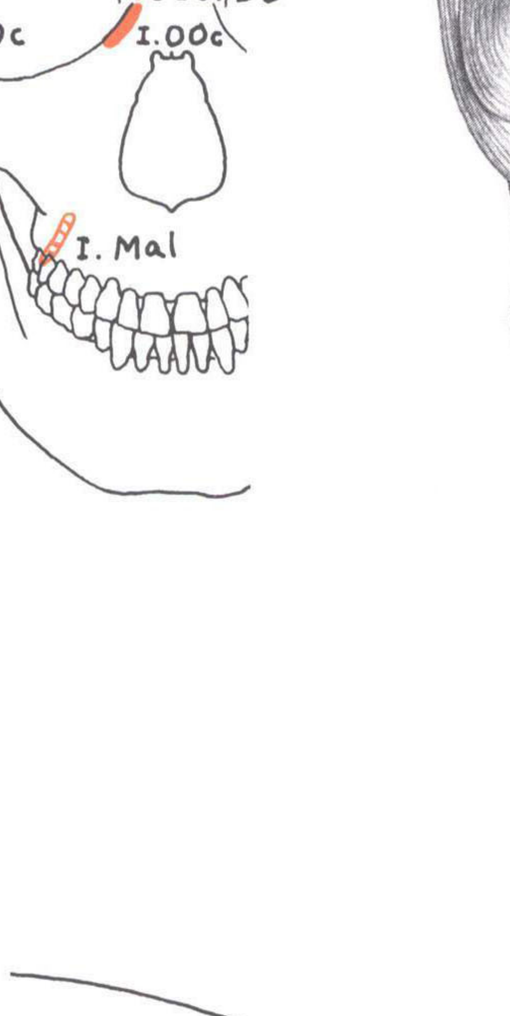
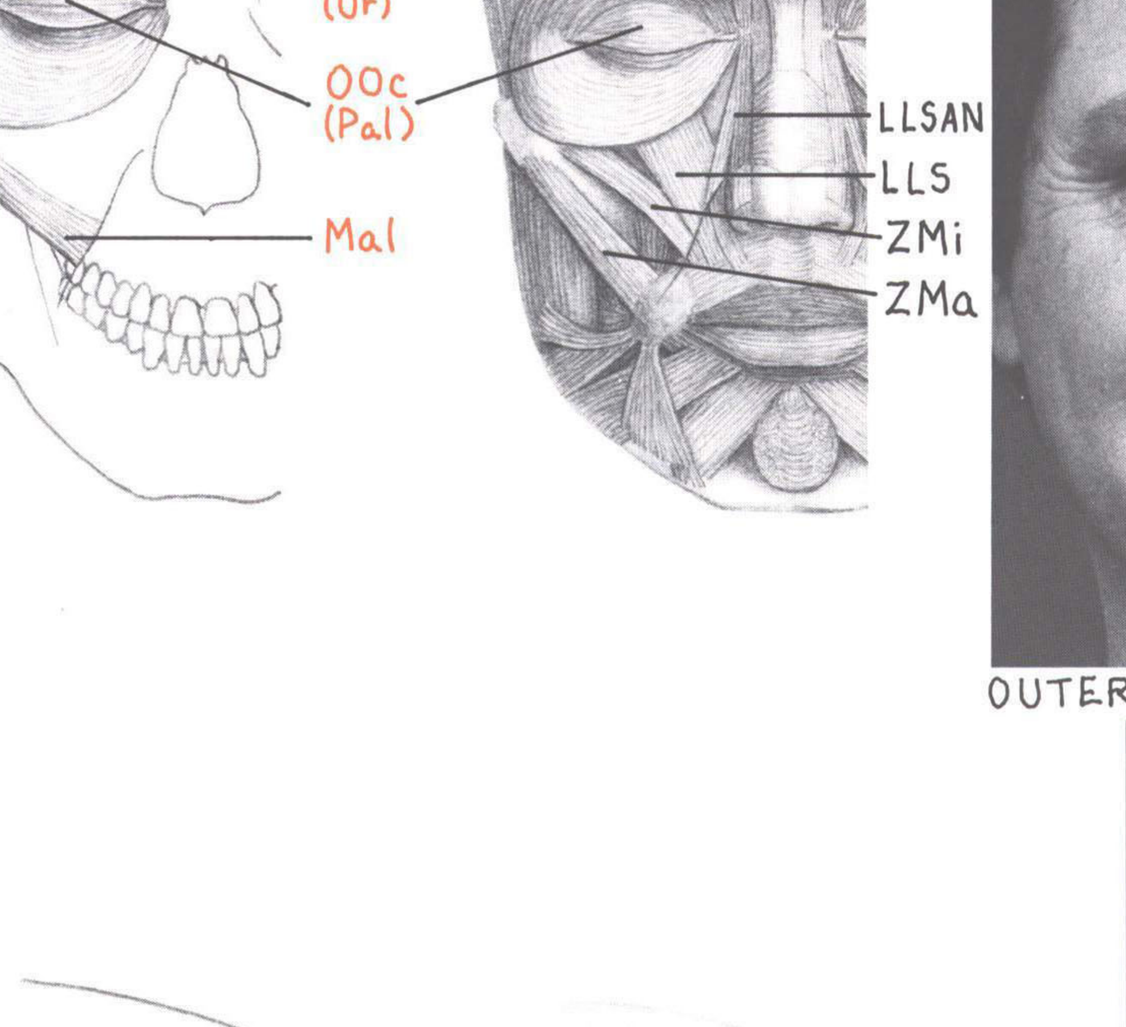
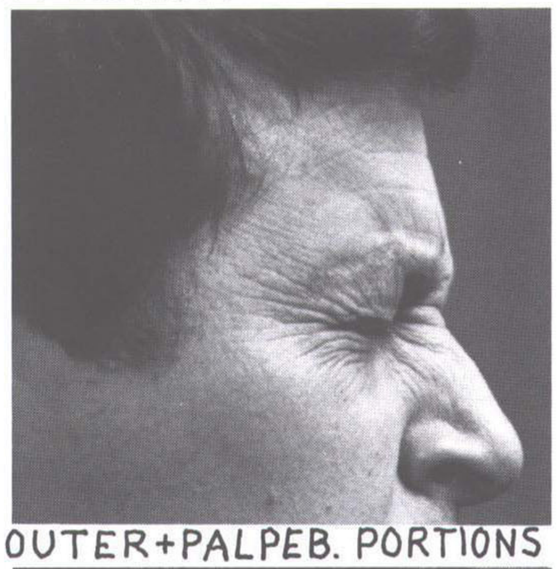
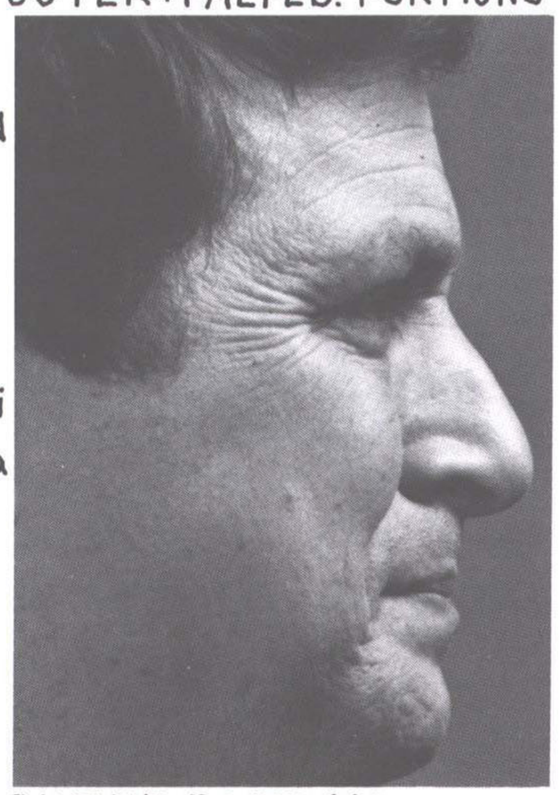






OUTER+PALPEB. PORTIONS



OUTER PORTION

DS *Depressor supercilii* **F** *Frontalis* **LLS** *Levator labii superioris*
LLSAN *Levator labii superioris alaeque nasi* **Mal** *Malaris* **OOc** *Orbicularis oculi*
OOc(Or) *Orbicularis oculi—orbital portion* **OOc(Pal)** *Orbicularis oculi—palpebral portion*
P *Procerus* **Te** *Temporalis* **ZMa** *Zygomaticus major* **ZMi** *Zygomaticus minor*

Orbicularis Oculi
(Orbicularis Palpebrarum)

STRUCTURE The orbicularis oculi is a thin, extensive oval or pear-shaped muscle that surrounds the eye and orbit. It extends from the bottom of the forehead down to the front of the cheek and from the inside of the bridge of the nose outward to the anterior portion of the temple. This muscle has five parts: a **palpebral portion,** an **orbital portion,** a **lacrimal portion,** a **peripheral portion** (the **malaris**), and the **depressor supercilii.**

The small, thin **palpebral portion** is located within the upper and lower eyelids.

The thicker **orbital portion** sits on and beyond the bony orbit. It is the main part of the orbicularis oculi, and the only part that is a sphincter. The upper fibers of the orbital portion fuse with fibers of the frontalis and corrugator supercilii.

The **lacrimal portion** is very small; it is located deep behind the inner corner of the eye. It does not affect either surface form or facial expression.

The **peripheral portion,** or **malaris,** is located just beyond the orbital portion, on its medial and lateral sides. It is often overlooked in the literature. It is made up of the most peripheral fibers of the orbicularis oculi. The malaris consists of separate medial and lateral portions, of which the lateral portion is the more important. The **medial malaris** lies on the levator labii superioris alaeque nasi and passes downward and laterally to insert into the cheek fat. Its effect on the surface is uncertain. The **lateral malaris** is a wide band that extends from the side of the temple to the middle portion of the nasolabial furrow. Part of it lies on top of the zygomaticus major. Both the zygomaticus major and lateral malaris are used in smiling, both together or the malaris alone. The lateral malaris will be referred to as the **malaris.**

The **depressor supercilii** is the upper medial portion of the orbicularis oculi. Its fibers lie in a vertical orientation and fan out superiorly from a small bony origin.

ORIGIN The **palpebral portion** originates from the bifurcation of the lateral end of the medial palpebral ligament. The medial palpebral ligament is a short fibrous ligament that attaches to the maxilla at the middle of the inner border of the orbit. The **orbital portion** of the orbicularis originates from the medial palpebral ligament and from the bone just *above* it. The **malaris** originates from the fascia of the temple on the side of the head, at about the level of the eye. The **depressor supercilii** has its own bony origin on the side of the root of the nose near the inner corner of the eye, adjacent to the origin of the orbital portion.

INSERTION The fibers of the **palpebral portion** insert into the lateral palpebral raphe (formed by the interlacing of its own upper and lower muscle fibers at the outer corner of the eye), which in turn attaches to the outer border of the bony orbit. The fibers of the **orbital portion** arch upward and outward, pass around the lateral side of the orbit, and return uninterrupted to the medial palpebral ligament and to the bone just *below* it on the inner border of the orbit. The **malaris** inserts into the middle portion of the nasolabial furrow and the adjacent cheek fat. The **depressor supercilii** inserts into the skin of the forehead at the medial end of the eyebrow, as well as blending with fibers of the procerus and frontalis.

ACTION The **palpebral portion** closes the eyelids. It lowers the upper eyelid and raises the lower eyelid (a nonsphincteric action because of the semirigid tarsal plates located in the eyelids). The lower eyelid alone may be raised while the upper eyelid is independently stabilized or raised by the levator palpebrae superioris. When the eye is gently closed, the lower eyelid stays in place while the upper eyelid is pulled downward. Upper eyelid droop, during drowsiness, is caused by relaxation of the levator palpebrae superioris, not by contraction of the palpebral portion of the orbicularis oculi.

The **orbital portion** partially or completely closes the eye by sphincteric action. Strong contraction protects the eyeball. It approximates the skin above and below the eye, lowering the eyebrow and raising the cheek, as in squinting and winking. It can independently raise the cheek without lowering the eyebrow. The orbital portion also draws the skin of the temple toward the eye.

Both portions of the orbicularis oculi are strongly contracted during violent actions such as sneezing, coughing, and screaming. Contractions of one or both parts, in either one or both eyes, produce a wink, blink, or squint.

The **malaris** is particularly important in that it raises the lower half of the nasolabial fold and raises and puffs out the cheek. Both are major components of smiling. When smiling, the muscular node at the angle of the mouth and the fatty cheek are pulled upward, outward, and backward. This is caused by two different muscles. The node is pulled by the zygomaticus major, and the cheek by the malaris. The zygomaticus major normally inserts only into the node, not into the skin (nasolabial fold) or cheek fat. If the node is pulled downward by the depressor anguli oris, the zygomaticus ma-

jor (its antagonist) relaxes and becomes stretched. The cheeks and nasolabial furrow, however, can still be pulled upward while the node remains in its lowered position. Since the zygomaticus major can't pull the cheeks upward because it is being elongated and held by the depressor anguli oris, the only muscle capable of pulling the cheek and nasolabial furrow upward (without pulling the upper lip) is the malaris. The expressions thus produced—the "suppressed or restrained smile" or the sad/happy blend—are common expressions. When the zygomaticus major is contracted, the malaris probably always contracts; however, as we have just seen, the malaris can apparently contract independent of the zygomaticus major.

The **depressor supercilii** pulls the medial end of the eyebrow downward, acting in conjunction with the corrugator supercilii and procerus.

EFFECT The orbicularis oculi narrows the eye opening, which may also reduce the amount of light passing through the pupil. Contraction of the entire muscle pulls the eyebrow and skin of the forehead downward and medially (smoothing the forehead), pulls the cheek for the most part upward and medially, and pulls the skin of the temple medially; in other words, the skin around the orbit is pulled toward the bony origin of the muscle on the side of the root of the nose. Contraction also creates or deepens the skin folds below the lower eyelid and creates distinct skin folds that radiate from the outer corner of the eye ("crow's-feet"). Skin wrinkles may also radiate from the inner corner of the eye onto the side of the upper end of the nose. Raising the cheek bulges the lower eyelid and pushes it upward on the eyeball.

Raising the lower eyelid—whether it is pushed up by the cheek (orbital portion) or pulled up by the palpebral portion—makes its edge appear straighter (front view). Pulling the upper eyelid halfway down makes its lower edge appear straight and horizontal (front view), while pulling it all the way down (closing the eye) makes its edge curve downward at its center; the edge now lies near the bottom of the eye, since the lower eyelid does not rise when the eyes are gently closed.

EXPRESSION *Orbital portion and malaris:* essential component of happiness (smiling and laughing). *Orbital portion only:* crying, and the expression of pain; also confusion, concentration, hostility. *Lower eyelid raised:* fear, sadness, skepticism, unpleasantness, anger.

Corrugator Supercilii

ORIGIN The bone at the medial end of the superciliary arch, near the upper inner corner of the orbit.

INSERTION The skin of the middle portion of the eyebrow, and the skin of the forehead immediately above it. The fibers interlace with fibers of the frontalis and orbicularis oculi.

ACTION Pulls the middle section of the eyebrow downward and medially in an oblique direction, thereby pulling the brows together. It usually works simultaneously with the procerus and depressor supercilii to lower the eyebrows and pull them together. It can work without these muscles, pulling the eyebrows together, when the eyebrows are raised by the frontalis. Both sides usually work together, except when one eyebrow is pulled downward and the other upward.

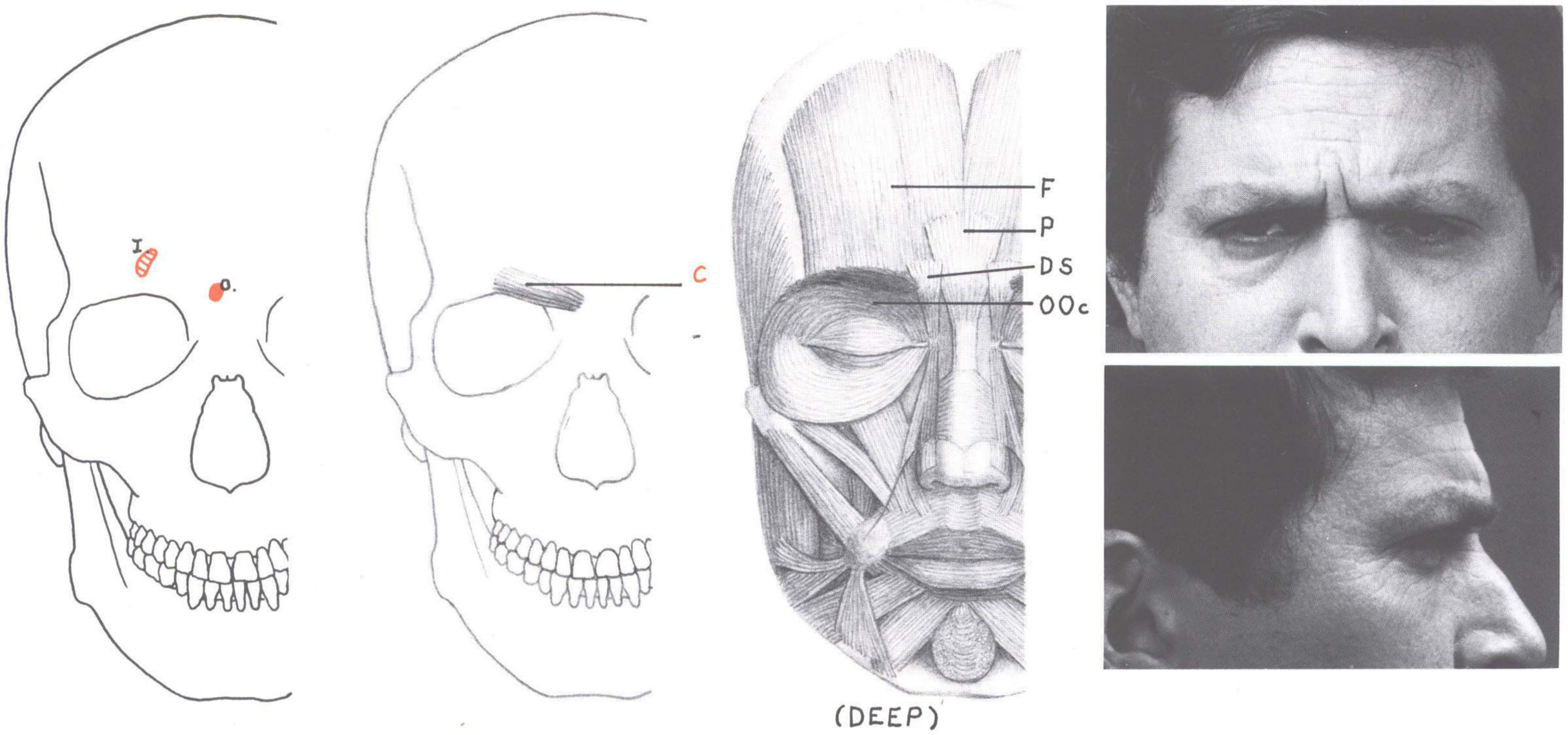
STRUCTURE The corrugator supercilii is a narrow, elongated muscle. Most of the muscle is deep to the orbicularis oculi, but the lateral tips of its fibers pierce the orbicularis to pass superficially and insert into the skin.

EFFECT The corrugator supercilii typically creates strong vertical or slightly oblique wrinkles and vertical bulges on the glabella between the medial ends of the eyebrows. It also swells the skin at the medial end of the eyebrow into a wide, thick, crescent-shaped bulge. This action pulls the brows shelflike over the eyes, shading them from strong light.

A depression forms in the skin above the middle of the eyebrow (actually closer to the medial end) as the corrugator contracts. It often gives the eyebrow an S-shaped curve—the eyebrow develops a central downward dip (usually close to the medial end) as the muscle pulls the middle portion of the eyebrow downward and inward. This is especially noticeable if the medial portion of the frontalis is also lifting the medial end of the eyebrow. The corrugator may also create a long, oblique, shallow furrow on the lateral side of the front of the forehead. This furrow is directed upward and outward from the medial end of the eyebrow or from the skin depression located above the middle of the eyebrow.

The lowering of the brow by the corrugator narrows the eye opening by pushing the skin below the eyebrow and upper eyelid downward.

EXPRESSION Anger; sadness, suffering, grief, pain; frowning; interest, thoughtful reflection, concentration (focused thought), curiosity, confusion. The corrugator can be considered a muscle of negative feelings, being typically used in sadness, fear, and anger. Concentration and determination, which also make strong use of the corrugator, may be regarded as unresolved stressful (negative) states.



CS *Corrugator supercilii* **DS** *Depressor supercilii* **F** *Frontalis* **OOc** *Orbicularis oculi* **P** *Procerus*

Levator Palpebrae Superioris

ORIGIN Deep in the back of the eye socket, from the roof of the orbit.

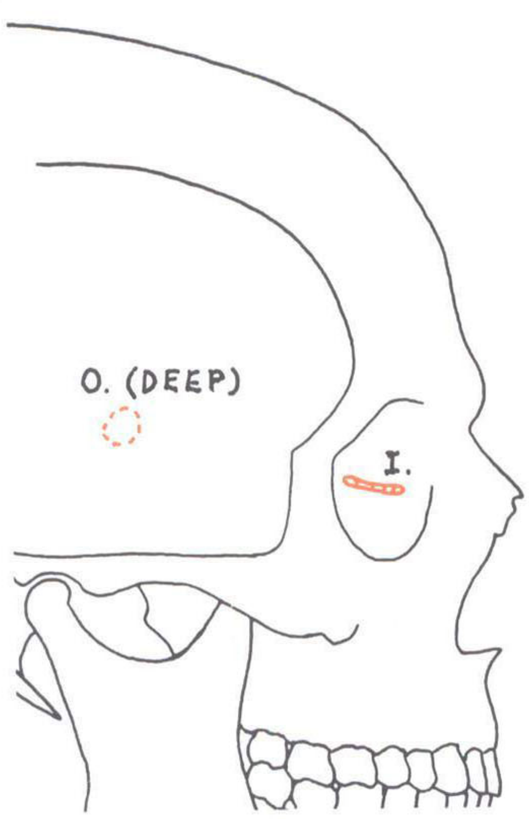
INSERTION The entire lower edge of the upper eyelid.

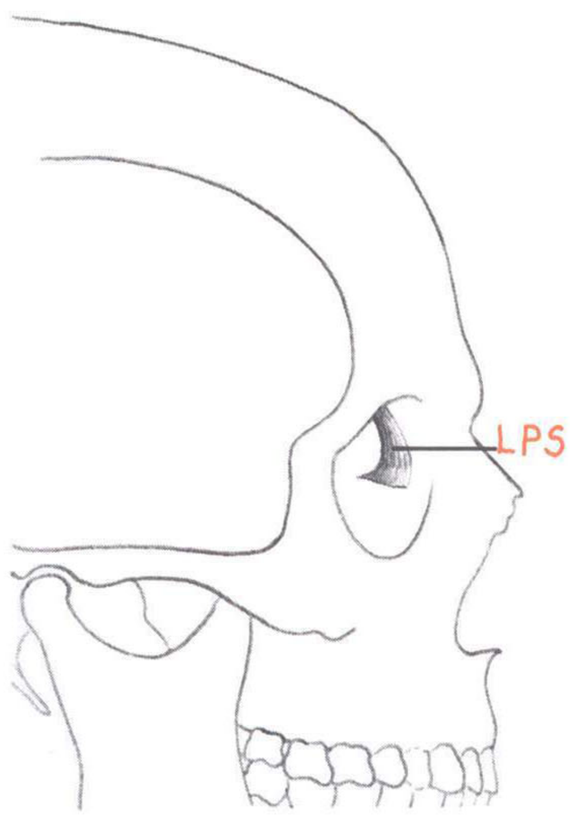
ACTION Raises the upper eyelid. It holds the eye open in the normal neutral position. Expression develops only after the eyelid has been raised above this position.

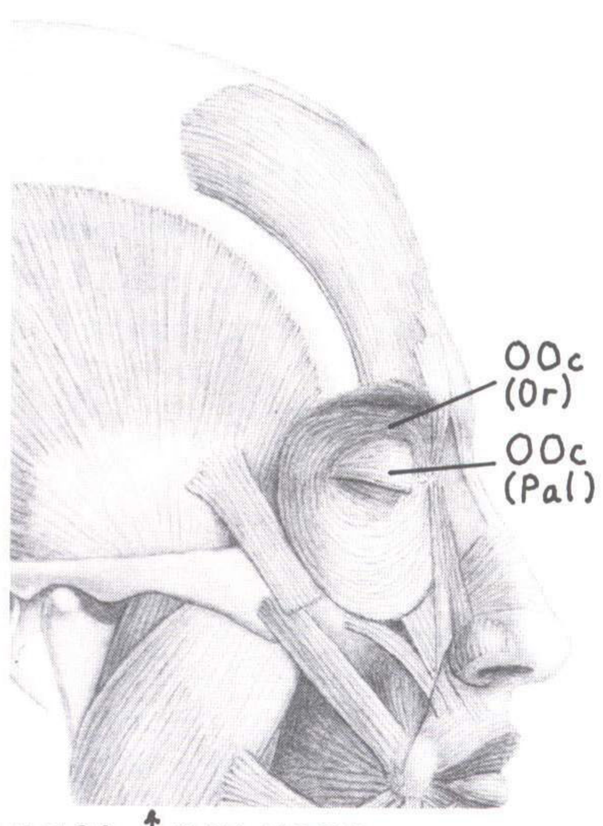
STRUCTURE The levator palpebrae superioris is a long muscle which passes over the eyeball, deep in the eye socket, along the roof of the orbit. Narrow behind, it widens as it advances anteriorly, becoming aponeurotic before inserting into the margin of the upper eyelid.

EFFECT Exposes the upper portion of the iris and the white of the eye (sclera) above the iris. By continued action it pulls the upper eyelid back so it disappears from view under the eye cover fold.

EXPRESSION Slight raising of the upper eyelid beyond the normal open eye produces a staring, fixed gaze or the expression of surprise. Full contraction produces intense expressions ranging from fear, terror, shock, astonishment, and intense joy to a blank, hypnotic look. Slight relaxation of the muscle (causing the upper eyelid to droop) with the eye still remaining partially open suggests drowsiness or intoxication, especially if the frontalis is also contracted in an attempt to hold the eyes open by raising the eyebrows. This expression exposes more of the upper eyelid, which has descended onto the upper portion of the iris. Upper eyelid droop and gentle eye closure (when the lower eyelid does not rise) are caused by relaxation of the levator palpebrae superioris, not by contraction of the orbicularis oculi.

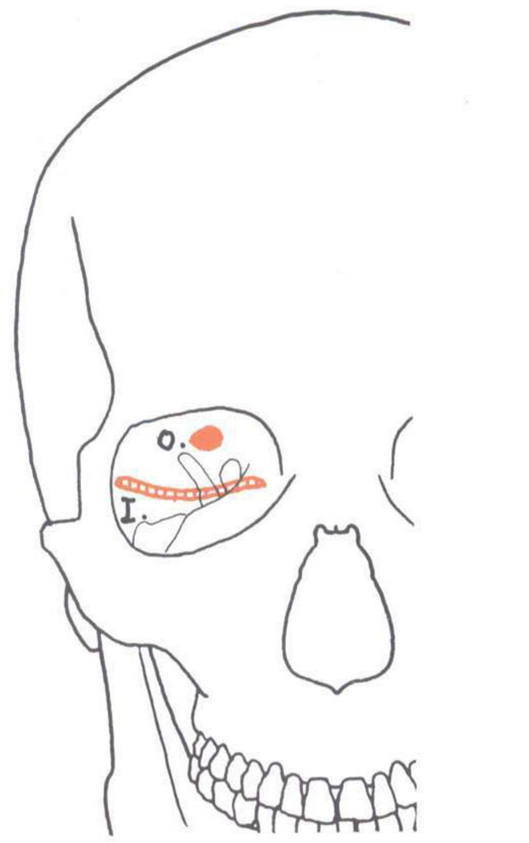


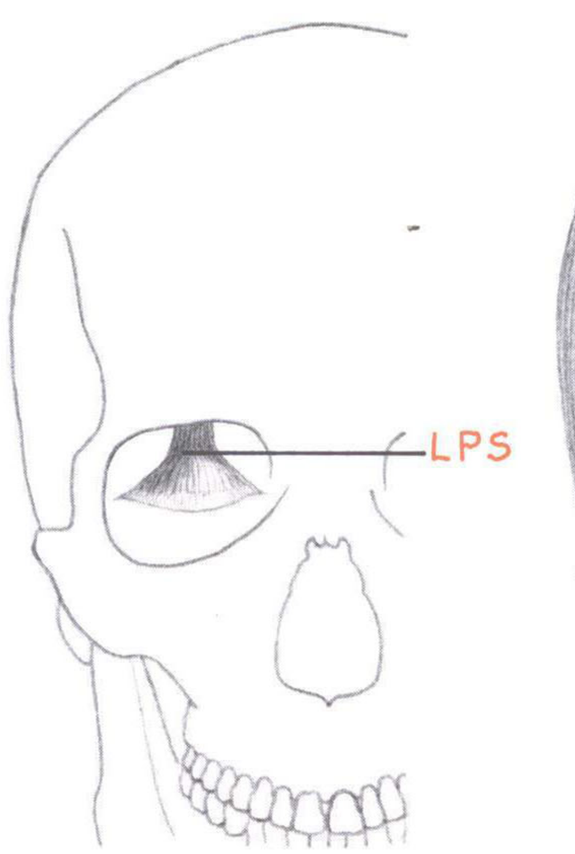


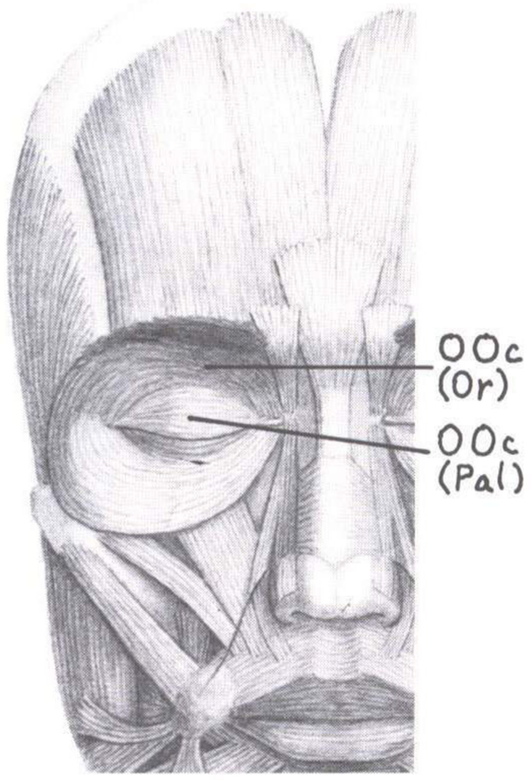


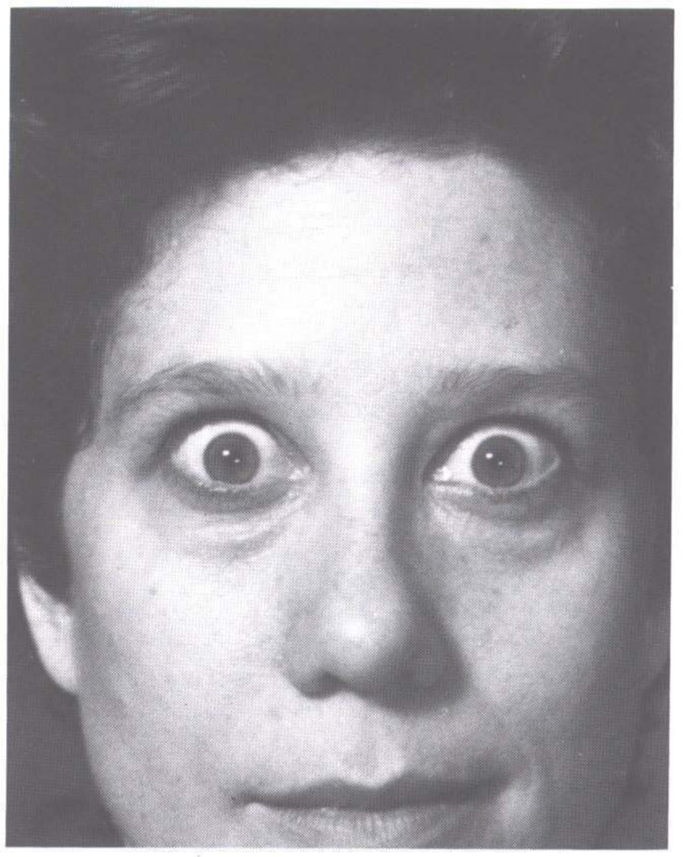
(DEEP) ↕ RELAXED

CONTRACTED ↕









DS *Depressor supercilii* **F** *Frontalis* **LPS** *Levator palpebrae superioris*

Procerus
(Pyramidalis Nasi)

ORIGIN The fascia covering the lower part of the nasal bones and the upper part of the lateral nasal cartilages.

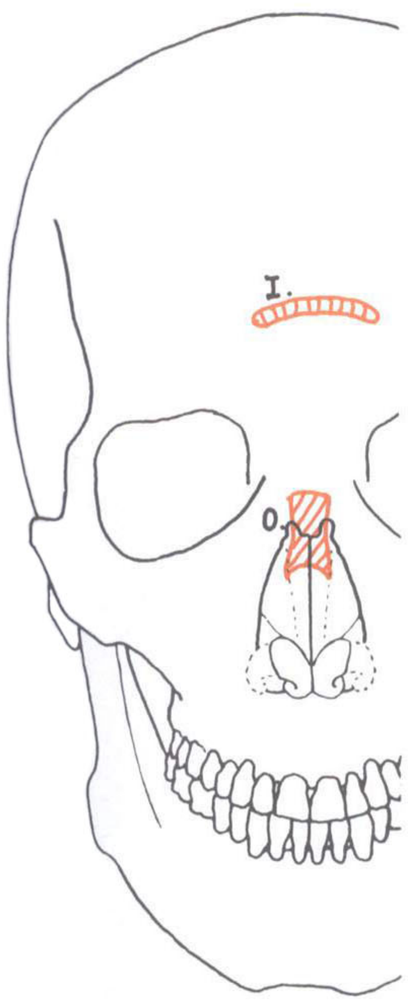
INSERTION The skin between the eyebrows and on the lower portion of the center of the forehead. Its fibers blend with fibers of the frontalis in the same region.

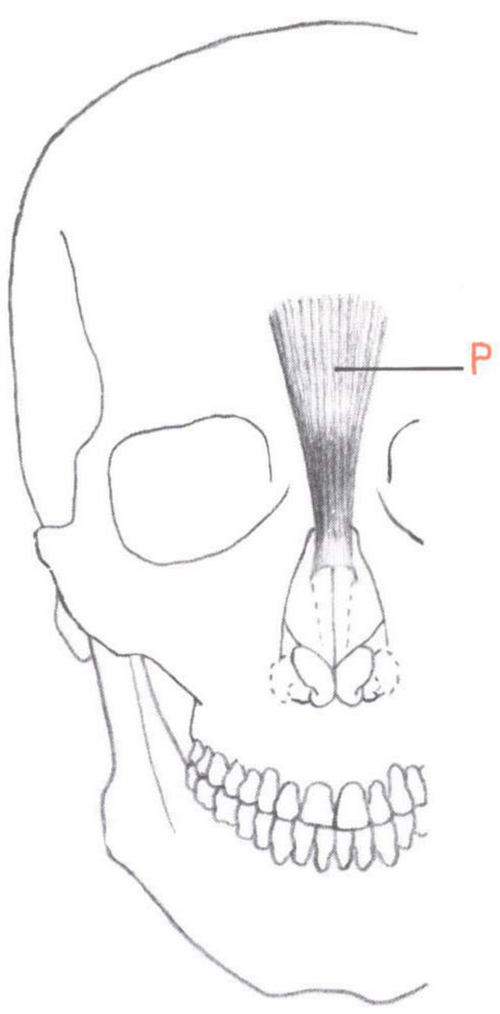
ACTION Pulls down the skin of the middle of the forehead and the medial ends of the eyebrows. This muscle works in conjunction with the corrugator supercilii and depressor supercilii to lower the medial ends of the eyebrows. The procerus automatically contracts when the levator labii superioris alaeque nasi is tensed. It can be seen working by itself if the eyebrows are first raised by the frontalis and then the levator labii superioris alaeque nasi is contracted.

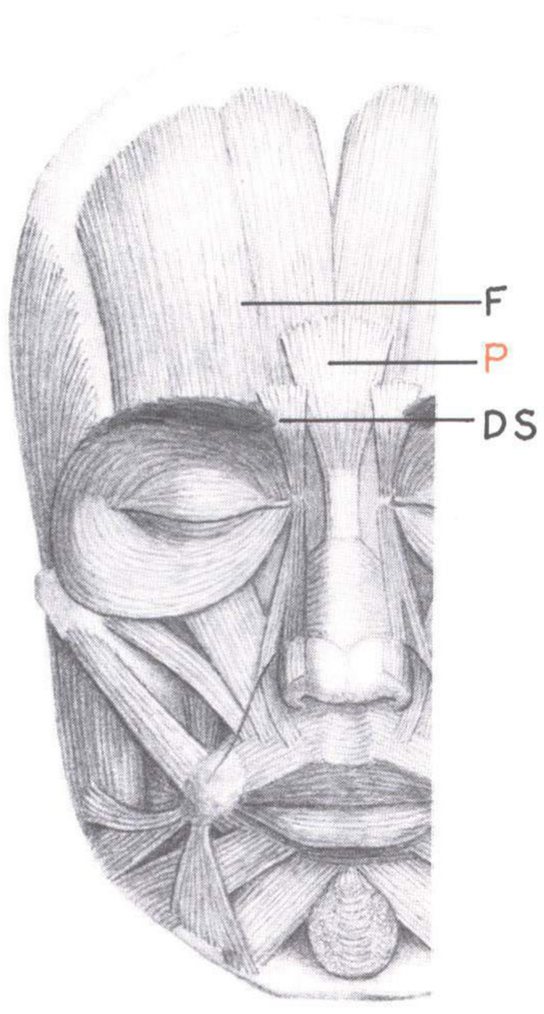
STRUCTURE The procerus muscles of both sides form a single triangular sheet of muscle between the eyebrows.

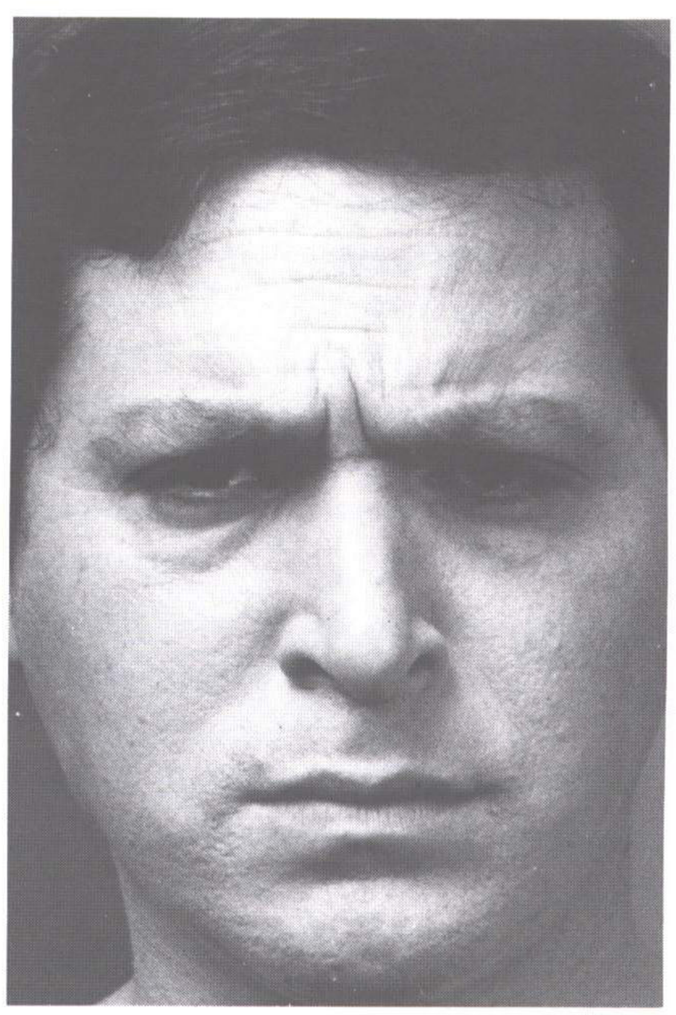
EFFECT The procerus may occasionally produce a horizontal wrinkle across the bridge of the nose.

EXPRESSION Anger, aggression, pain; frown, concentration; contributes to disgust.

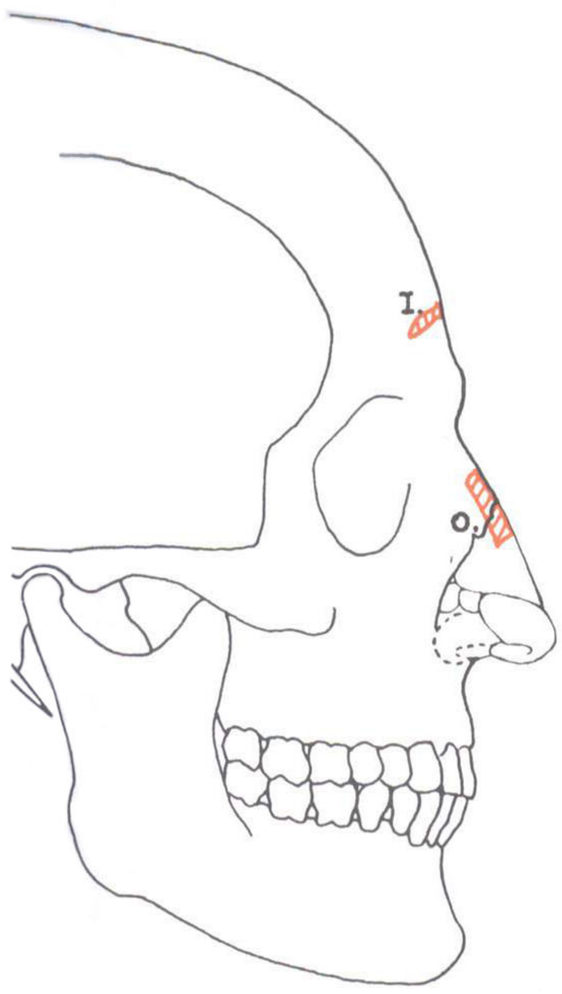


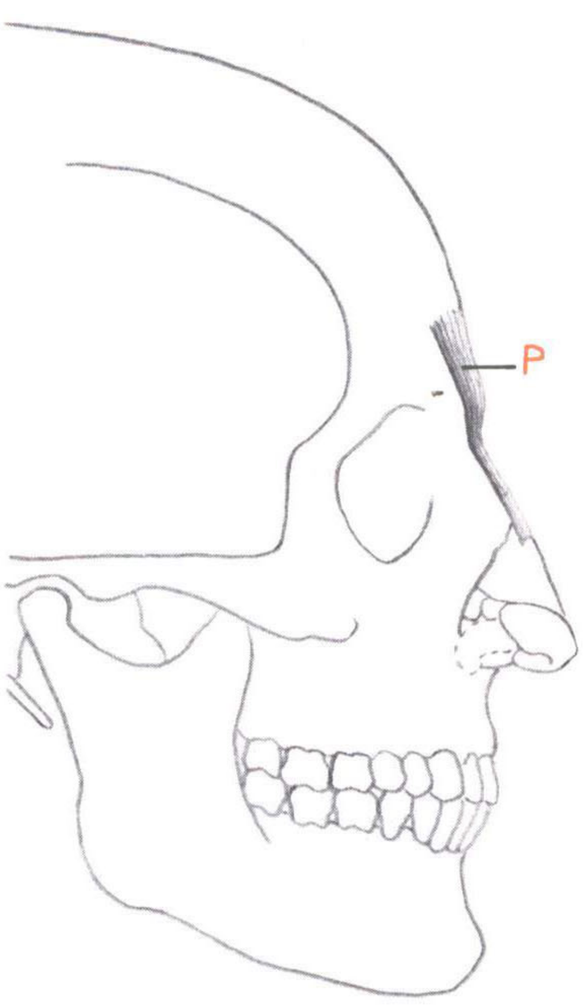


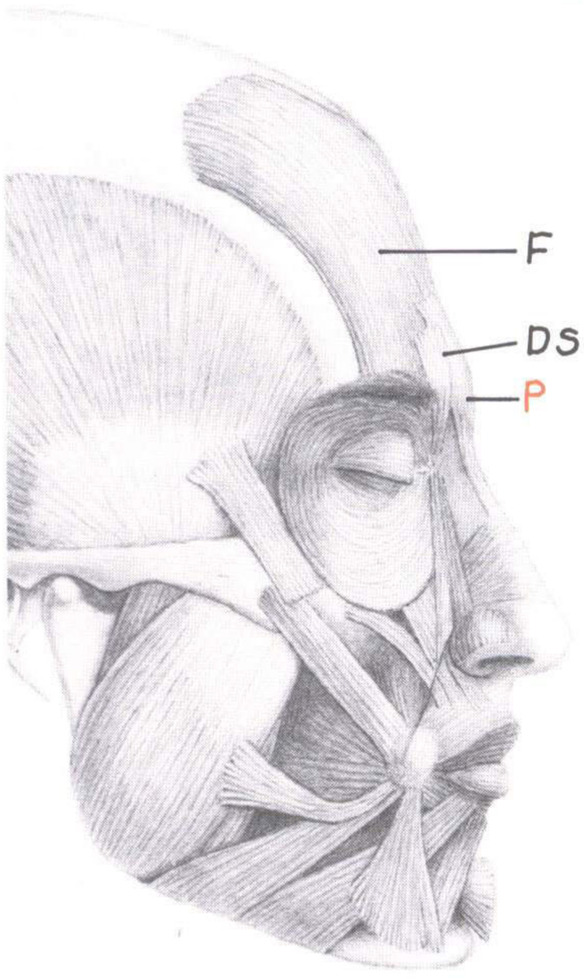


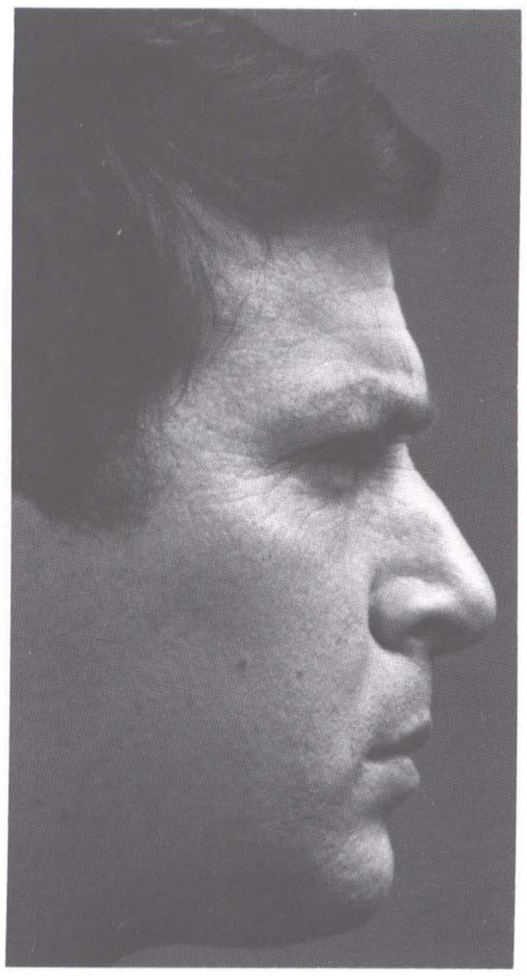


PROCERUS + CORRUGATOR ↕

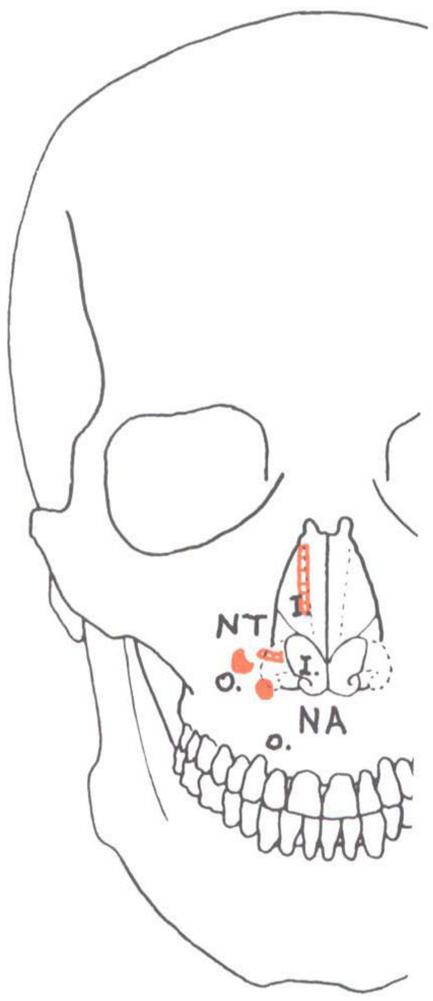


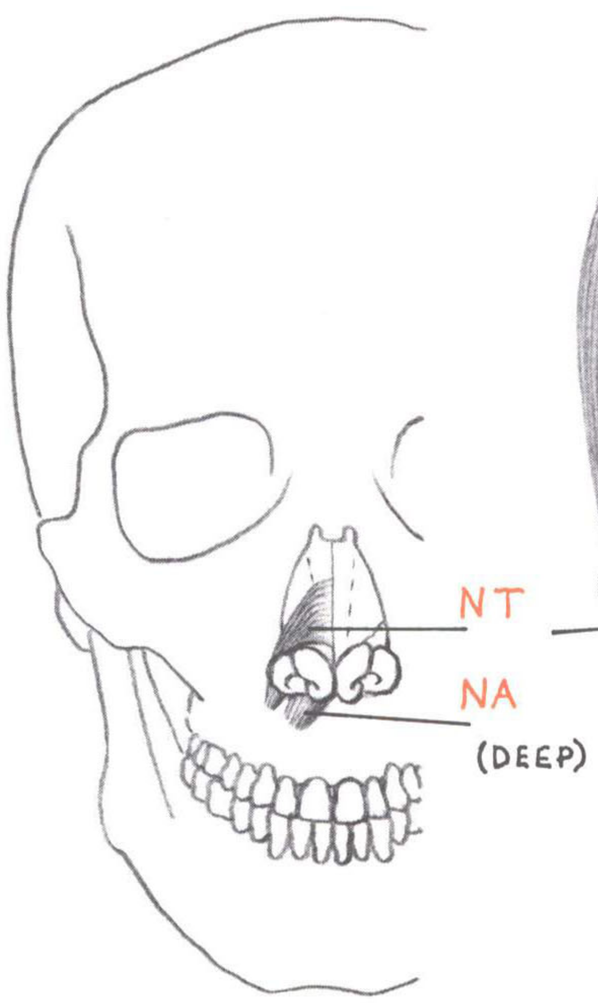


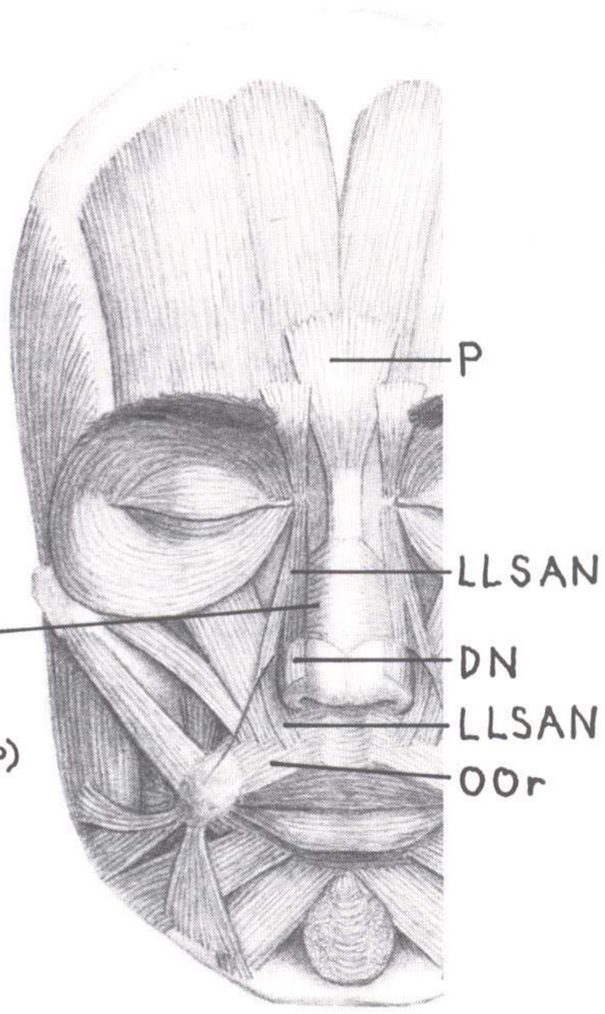


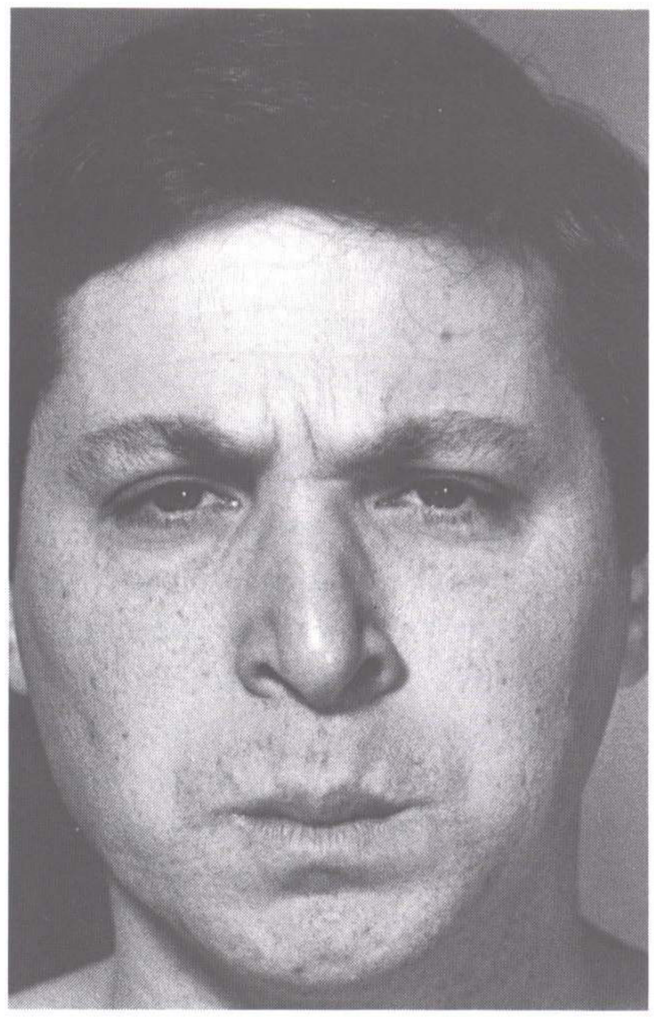


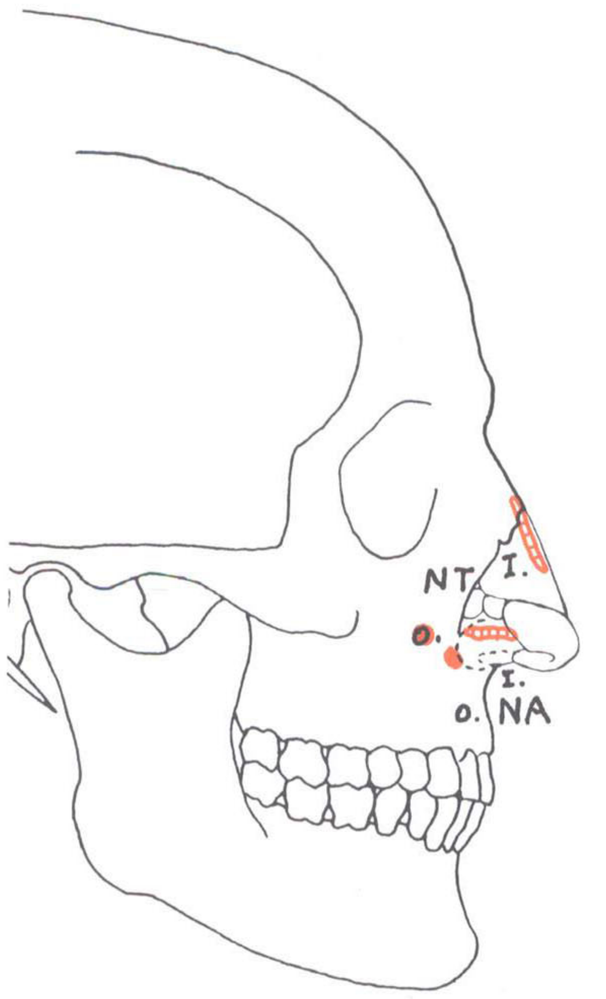
OOc(Or) *Orbicularis oculi—orbital portion* **OOc(Pal)** *Orbicularis oculi—palpebral portion* **P** *Procerus*

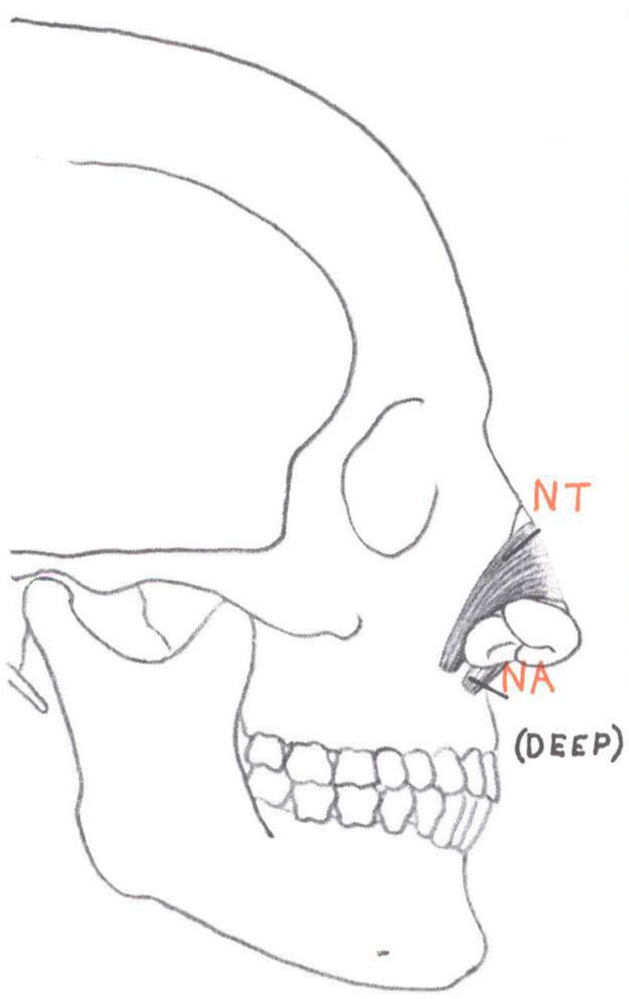


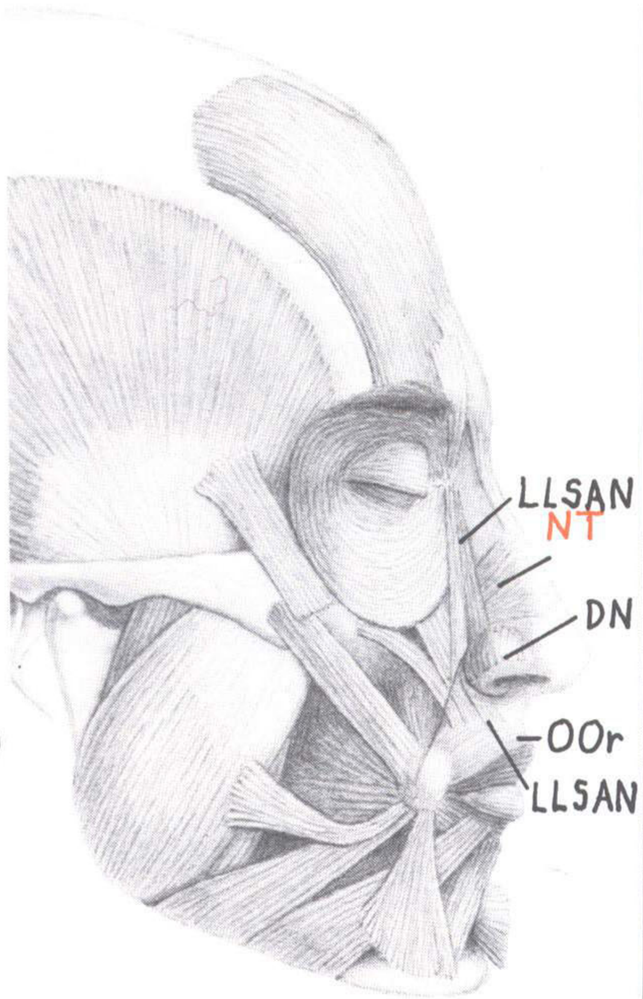












DN *Dilator naris* **LLSAN** *Levator labii superioris alaeque nasi* **NA** *Nasalis—alar part*
NT *Nasalis—transverse part* **OOr** *Orbicularis oris* **P** *Procerus*

Nasalis—Transverse Part (Compressor Naris)

ORIGIN The front of the maxilla, just below and lateral to the base of the nasal opening.

INSERTION Continuous with the same muscle of the other side of the face. The two muscles fuse over the middle section of the front edge of the nose (over the cartilaginous part).

ACTION The originating and inserting ends of the transverse part do not move; therefore, when the transverse part contracts, its belly straightens between its two fixed points of attachment. Since neither end moves, the muscle flattens ("compresses") the side of the nose (not the nostrils). The muscle automatically contracts when the lips are strongly pressed together. Both transverse parts, on each side of the face, contract simultaneously.

STRUCTURE The transverse part of the nasalis is a thin muscle that hooks behind (posterior to) the wing of the nose (deep to the levator labii superioris alaeque nasi, close to the skull) and then widens into a triangular shape as it passes upward, forward, and medially on the side of the nose. It ends in a wide aponeurosis.

EFFECT The skin on the side of the nose, and the wing of the nose, are pulled downward and backward. The wing of the nose becomes more pronounced.

Nasalis—Alar Part (Depressor Alae Septi)

ORIGIN The front of the maxilla, a short distance below the nasal opening (above the lateral incisor tooth). This origin is adjacent and medial to the origin of the transverse part of the nasalis.

INSERTION The skin at the posterior end of the wing of the nose, the skin at the lower (posterior) margin of the nostril, and the skin of the mobile septum of the nose at the midline.

ACTION Pulls its insertion points downward. Both alar parts of the nasalis, on each side of the face, contract simultaneously. When the lips are pressed together, the alar parts of the nasalis assist in pushing the upper lip downward, in much the same way the mentalis pushes the lower lip upward.

STRUCTURE The alar part of the nasalis is a short, wide muscle. It is covered by the upper portion of the orbicularis oris.

EFFECT Contraction of the alar part thins the fleshy nasal septum between the nostrils when pulling it downward. It also pulls the tip of the nose downward and indirectly pushes the lower lip downward. By pulling the posterior margin of the nostril downward, the nostril becomes slightly enlarged and rounded. This may account for the fact that the alar part, which does not flare the nostril, has erroneously been called the dilator naris. The dilator naris and the nasalis can contract independently of each other.

EXPRESSION There is no specific expression associated with the nasalis.

Both the transverse and alar parts of the nasalis seem to always contract together, and are frequently used in speech when the lips are pressed together (e.g., in pronouncing "B" and "P" sounds).

Dilator Naris
(Alaris)

ORIGIN Edge of the nasal notch of the maxilla (bony origin) and the lesser alar cartilages and lower edge of the lateral crus of the greater alar cartilage (cartilaginous origins).

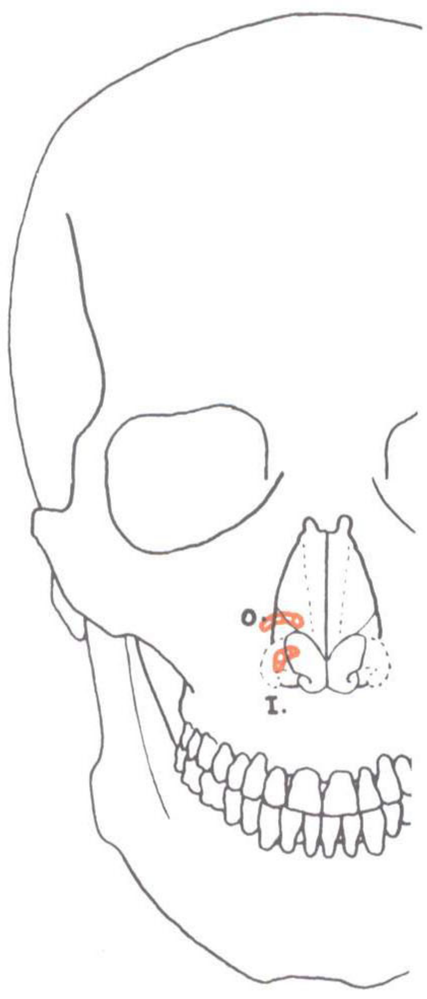
INSERTION The skin at the inferior margin of the wing of the nose.

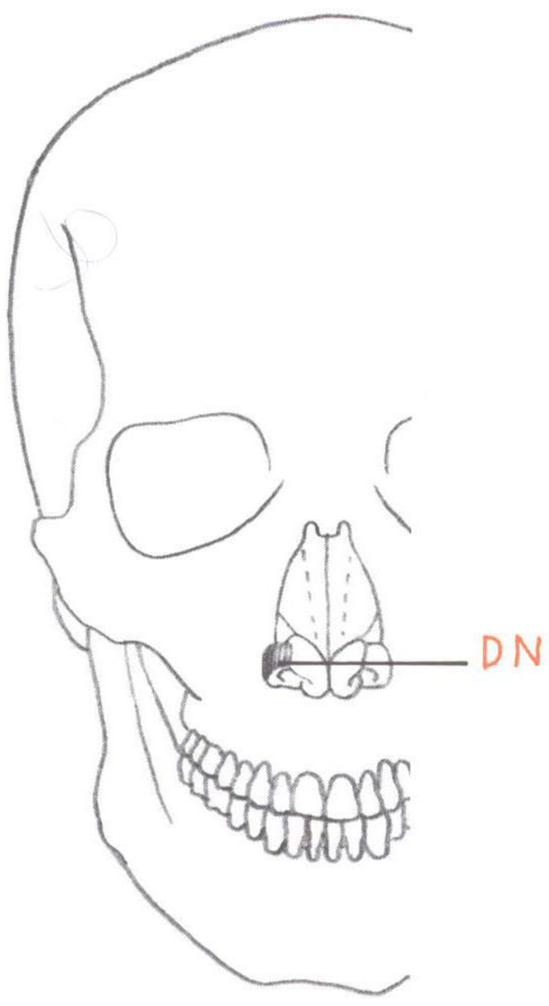
ACTION Dilates (flares) the wing of the nose. Both sides work simultaneously.

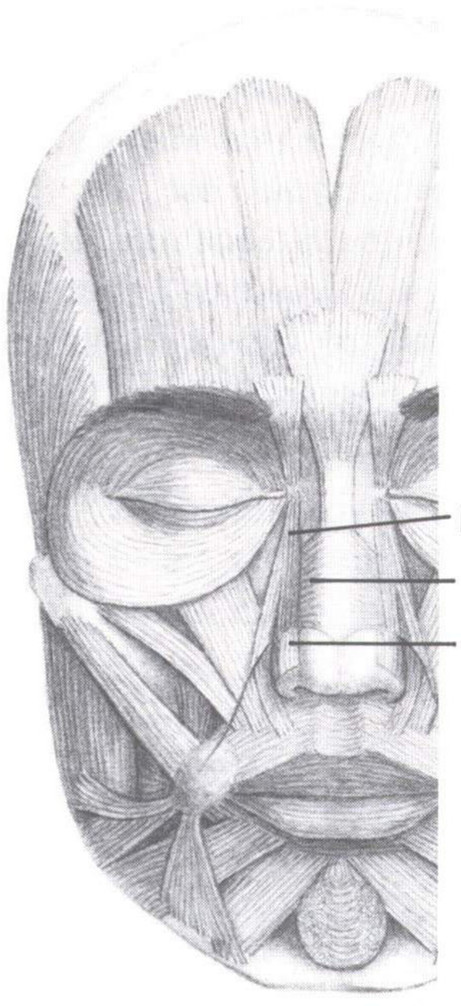
STRUCTURE The dilator naris is a very thin rectangular muscle that lies on the outer surface of the wing of the nose.

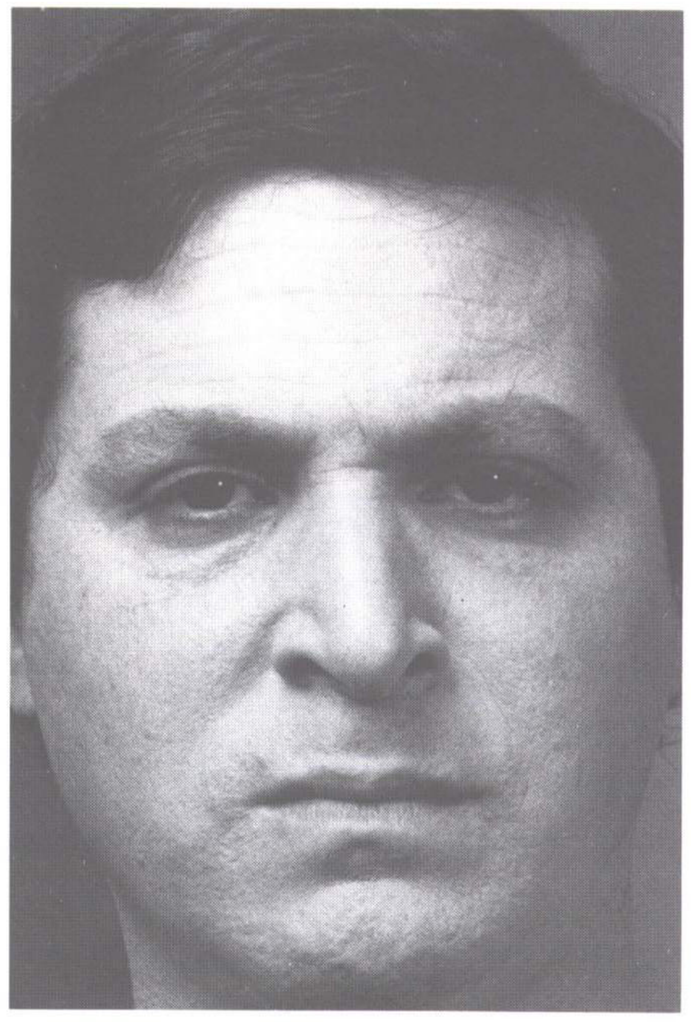
EFFECT Enlarges the opening of the nostril. The upper edges of the wings of the nose become depressed (pulled medially), and the furrow at the upper edge of the wing becomes more pronounced. In side view, the middle of the lower edge of the wing is raised, exposing more of the nostril.

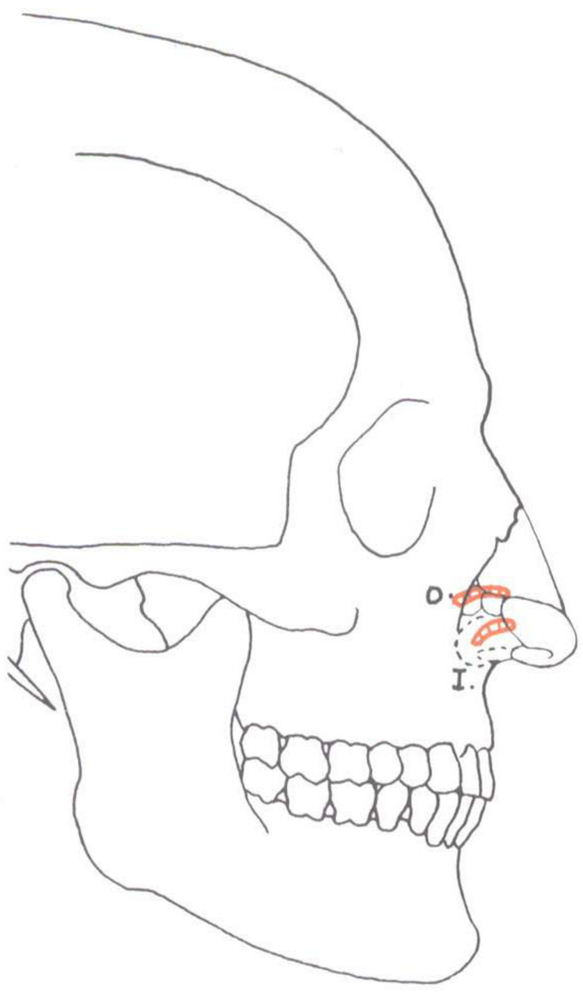
EXPRESSION Passion; anger, rage; labored breathing, exertion.

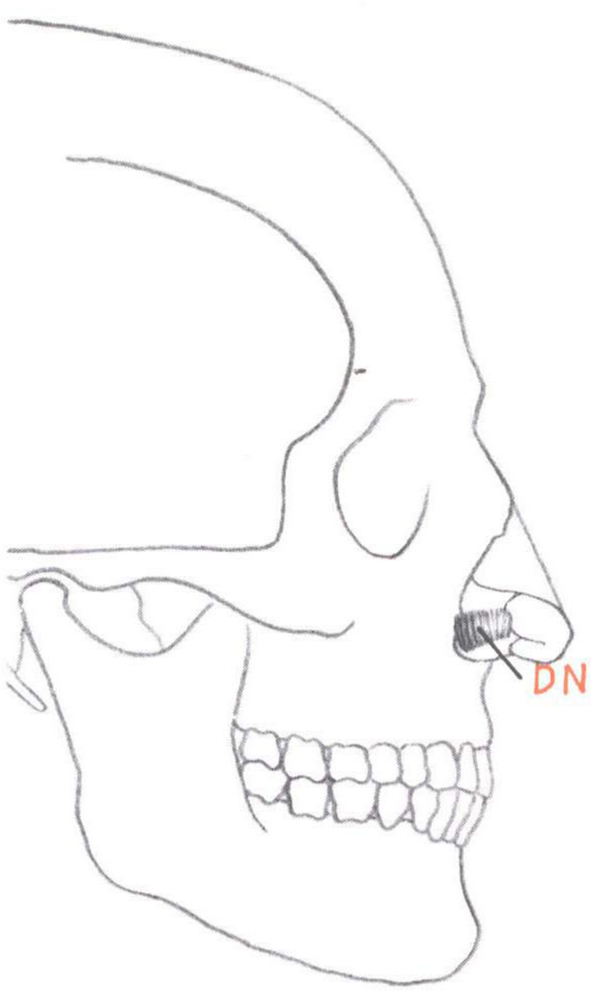


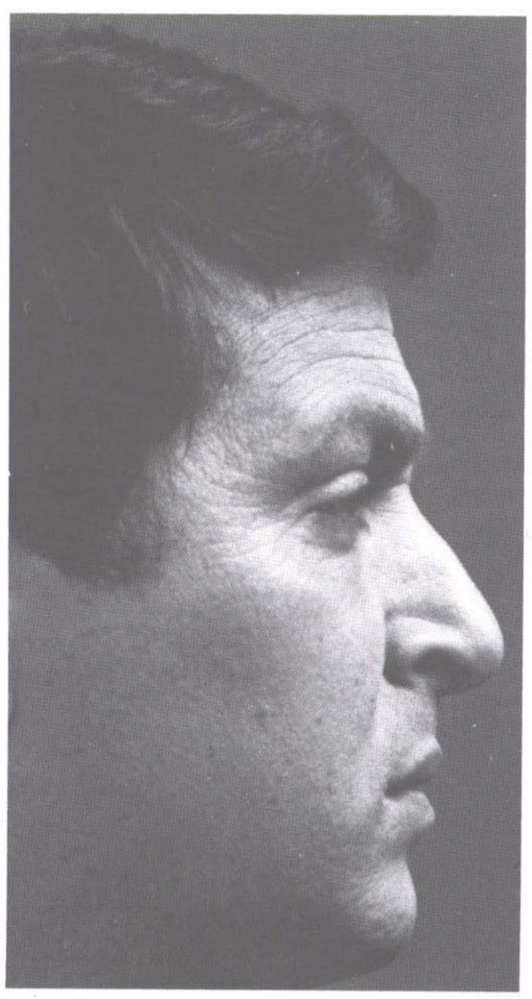












DN *Dilator naris* **LLSAN** *Levator labii superioris alaeque nasi* **NT** *Nasalis—transverse part*

Orbicularis Oris

STRUCTURE The mouth, primitively prehensile, has evolved into a most refined organ of expression and speech. The orbicularis oris, which forms the mouth proper, is the most complex of the facial muscles. It is a thick muscular mass that covers an area larger than the red lip portion of the mouth, extending upward to the base of the nose and downward to the beginning of the chin (down to or just below the mentolabial sulcus).

The orbicular oris is not a sphincter muscle, but is divided into an upper lip portion and a lower lip portion. These are further subdivided into **outer** (peripheral) and **red lip** (marginal) **portions.** The red lip portions consist of fibers located within the red portion of the lips. The outer portions are wider bands of fibers that are situated beyond the red part of the lips. In other words, there are four parts to the orbicularis oris: the red lip portion of the upper lip, the red lip portion of the lower lip, the outer portion of the upper lip, and the outer portion of the lower lip. Each part passes continuously from the muscular node on the left side of the face to the node on the right. These four parts can function either independently or together.

The **red lip portions** of the upper and lower lips are flattened bands that advance forward to lie on the *front* of the outer portions of the orbicularis at the midline of the face. Laterally, they curve around deep to the lateral ends of their respective outer portions, disappearing from view before inserting into the deep aspect of the nodes. The twisting of the red lip portions around the outer portions in both lips is clearly seen in life at the angle of the mouth. It is theorized that through evolution the mouth has been everted from its earlier configuration of a simpler slitlike mouth (where all the orbicularis fibers were parallel) to its present structure where the internal red mucous membranes have been pulled forward and exposed (the current red part of the lips is a toughened form of what was once a more delicate internal mucous membrane).

The **outer portions** are wider and more massive bands that taper laterally as they converge into the nodes. They are widest (highest) at the midline. The lower lip's outer portion inserts into the node at a slightly deeper plane than does the upper lip's outer portion. This gives the appearance that the upper lip overlaps the lower lip slightly at the angle of the mouth.

The fibers of the orbicularis oris are penetrated by the deep fibers of the upper and lower labial tractors (the superficial fibers of the labial tractors lie on top of the orbicularis oris, continuing all the way, or almost all the way, to the red lip margin).

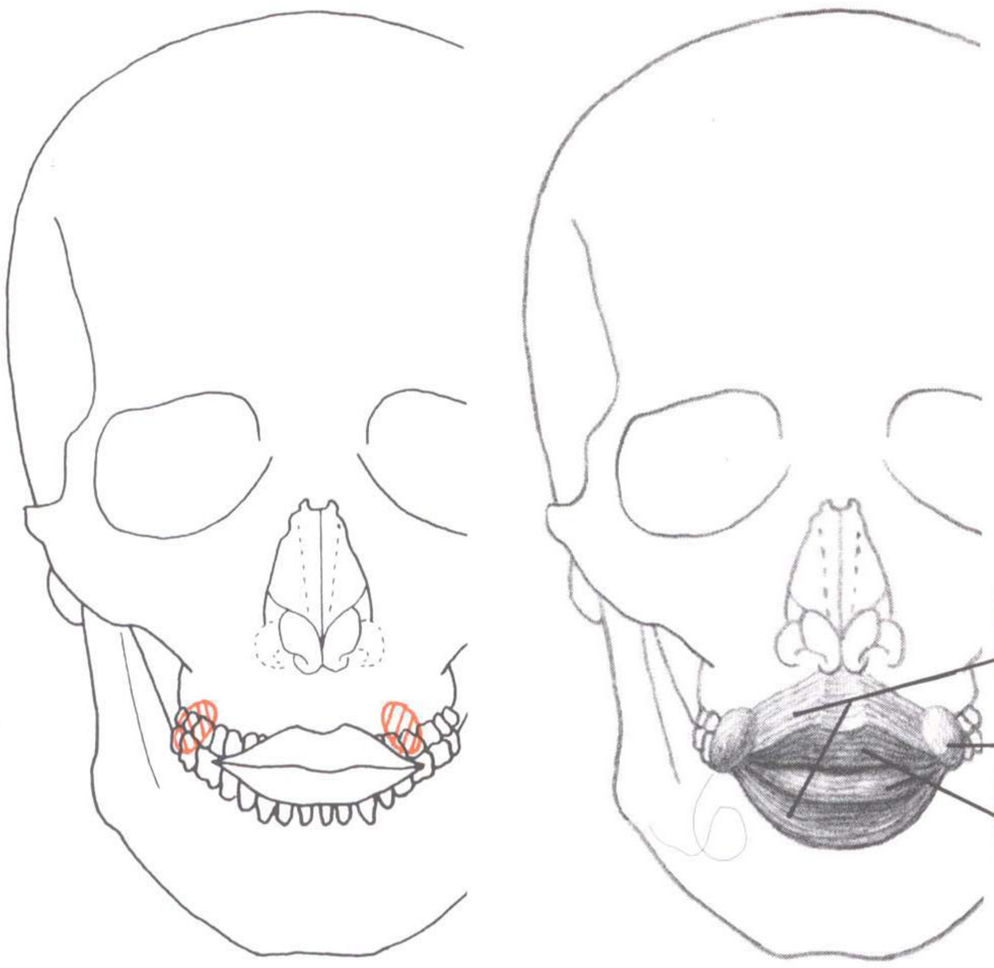
The midline bump of the red part of the upper lip, the **tubercle,** is fatty tissue, not muscle fiber. The ridges on the lateral ends of the lower lip near the angle of the mouth, which separate the red part from the skin below, are fibrous tissue, not muscle fiber. Fibrous ridges often border the entire length of the edges of both lips, not just the lateral ends of the lower lips.

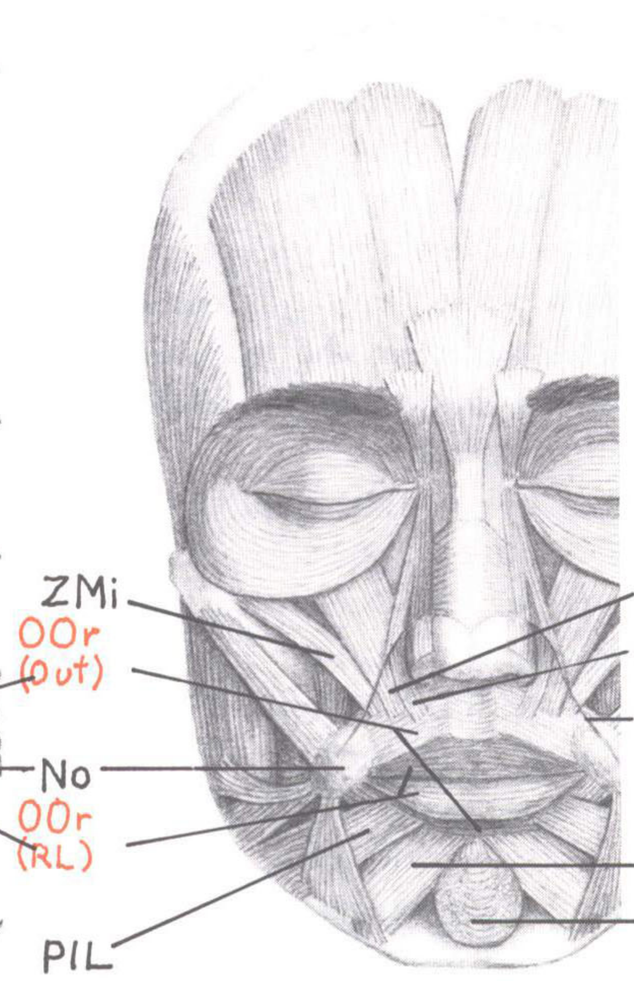
ATTACHMENTS The lateral ends of all four portions of the orbicularis oris simply attach to the muscular nodes at the angles of the mouth. The nodes function as movable points of attachment for the orbicularis oris; other facial muscles insert into the nodes and move them into various positions, such as upward or downward, medially or laterally, anteriorly or posteriorly, and then stabilize them.

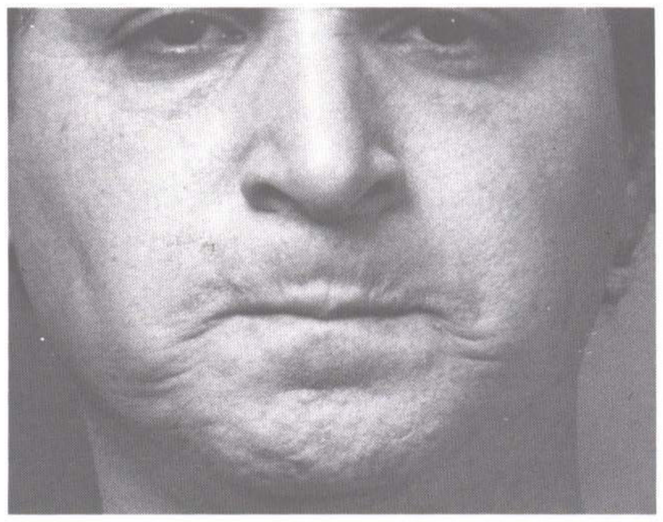
ACTION The orbicularis oris muscle is not a true sphincter muscle (continuous circular muscular ring), but may appear to function as such because it does close a body opening. It actually functions as four independent, elongated muscle bands.

Each of the four portions of the orbicularis oris spans the area between the nodes on either side of the face. Because these portions do not span straight across between their two points of attachment, but rather have curvatures in their normal resting positions (the upper lip portions curve upward and forward, the lower lip portions curve downward and forward), they simply attempt to become straight when they are contracted. Thus, the central area of the wide outer portion of the upper lip moves downward (and backward), and the central portion of the wide outer portion of the lower lip moves upward (and backward). These actions press the lips together if the mouth is closed, whether or not the red lip portions have been contracted. If the mouth is open, the outer portions can bring the upper and lower lips together, while still leaving space between the lips. If the lips have been funneled or puckered by the incisivus muscles (with the mouth remaining open), the round mouth opening can be closed by the outer portions, as when closing the mouth just prior to making a kissing noise (the red lip portions will remain relaxed in this case). When the lips are pressed tightly together, the orbicularis oris of the lower lip is assisted by the mentalis, which pushes it upward, while the upper lip may possibly be assisted by the alar portion of the nasalis, which may push it downward.

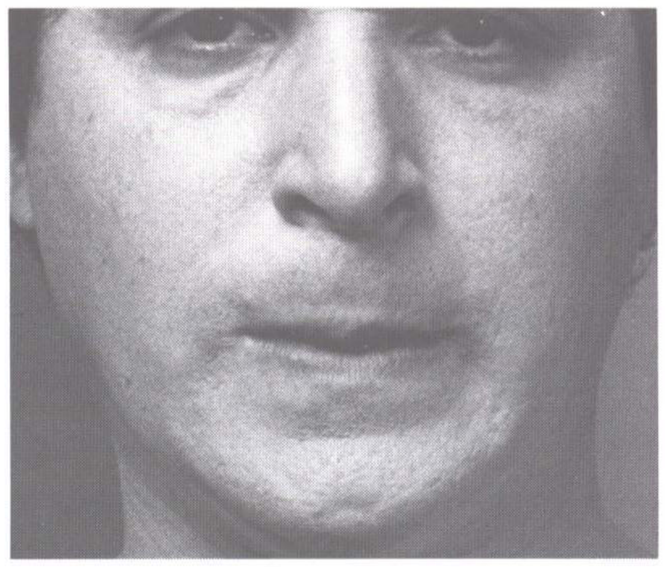
When the **red lip portions** alone are contracted, they invert the red parts of the lips, pulling them into the mouth and tensing them. This happens because the central muscle fibers of the red lip portions of each lip sit anterior to



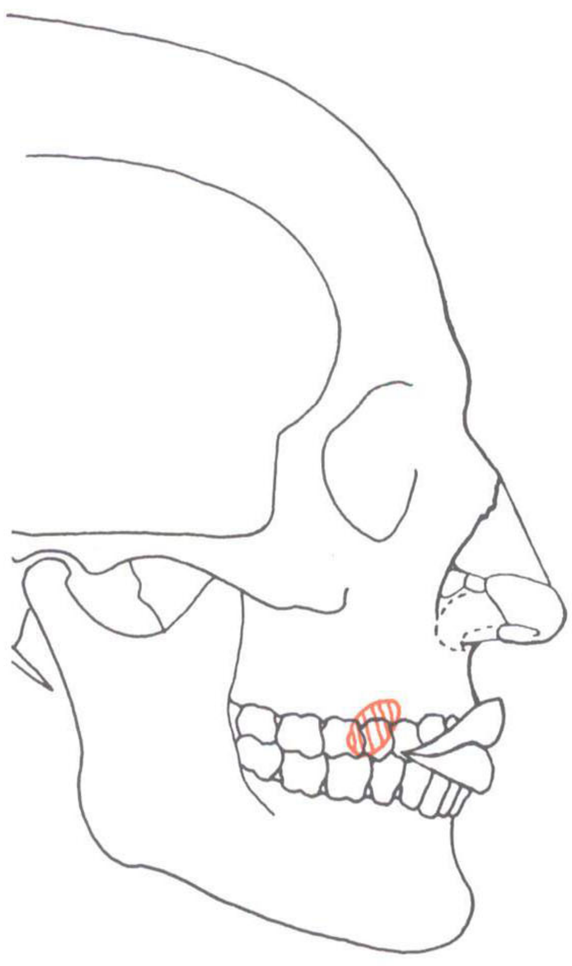


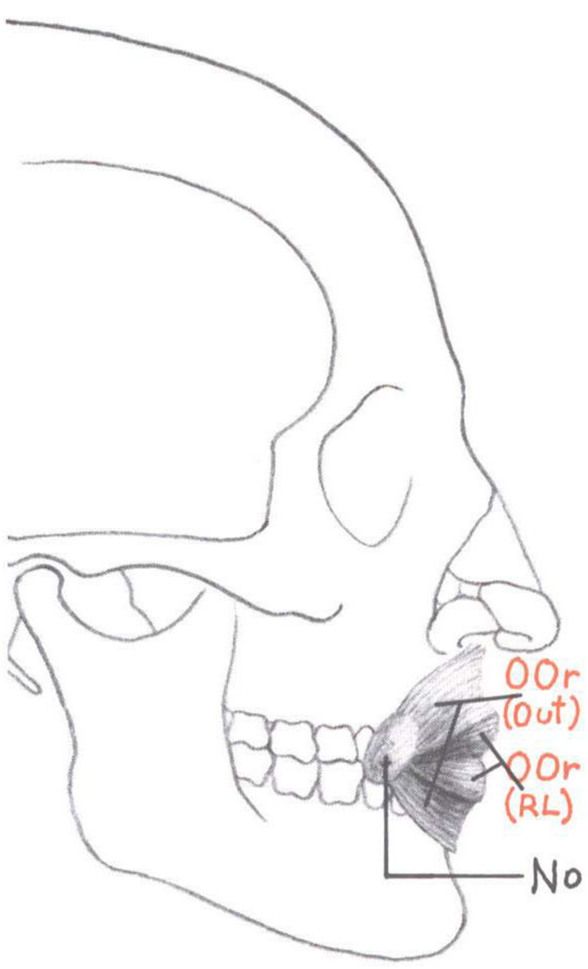


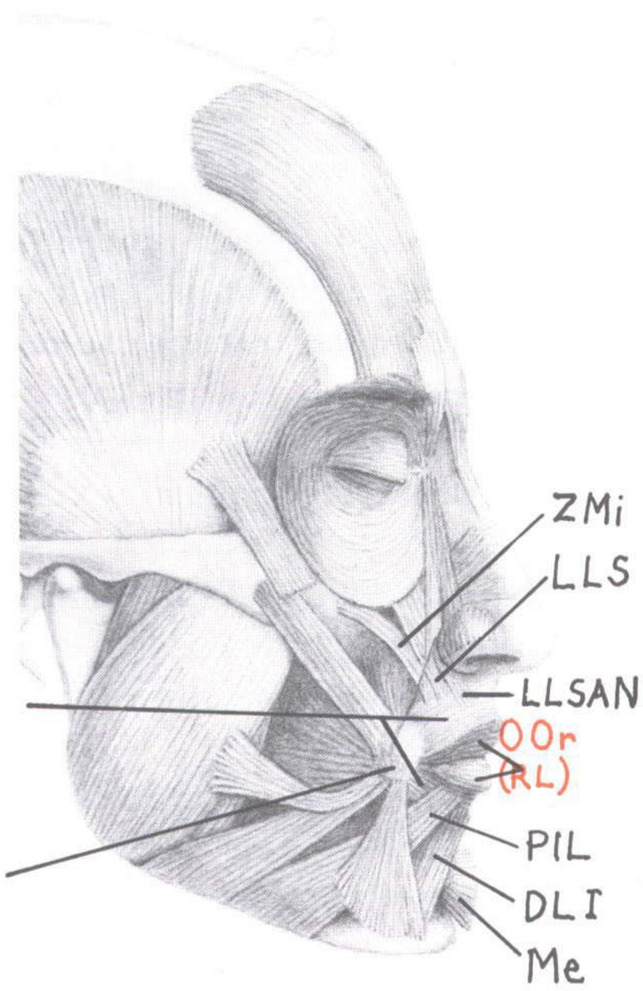
OUTER PORTION

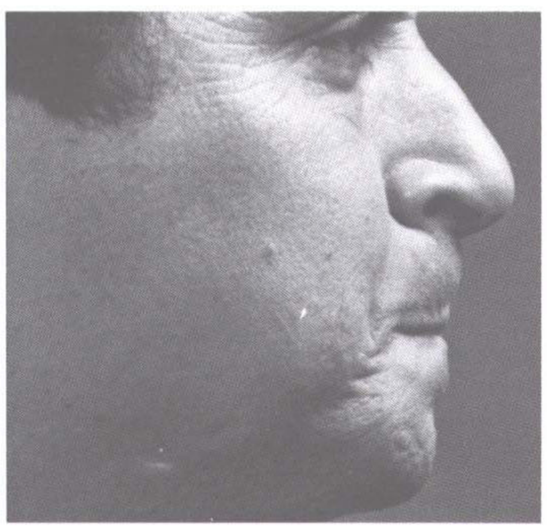


RED LIP PORTION









OUTER PORTION

RED LIP PORTION

DLI *Depressor labii inferioris* **LLS** *Levator labii superioris* **LLSAN** *Levator labii superioris alaeque nasi*
Me *Mentalis* **NLF** *Nasolabial furrow* **No** *Node* **OOr(Out)** *Orbicularis oris—outer portion*
OOr(RL) *Orbicularis oris—red lip portion* **PlL** *Platysma—labial portion* **ZMi** *Zygomaticus minor*

Orbicularis Oris

STRUCTURE The mouth, primitively prehensile, has evolved into a most refined organ of expression and speech. The orbicularis oris, which forms the mouth proper, is the most complex of the facial muscles. It is a thick muscular mass that covers an area larger than the red lip portion of the mouth, extending upward to the base of the nose and downward to the beginning of the chin (down to or just below the mentolabial sulcus).

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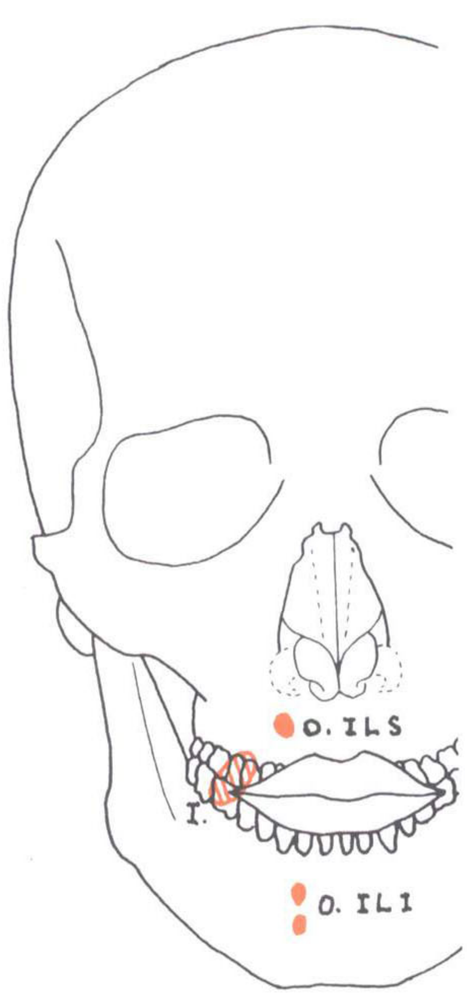
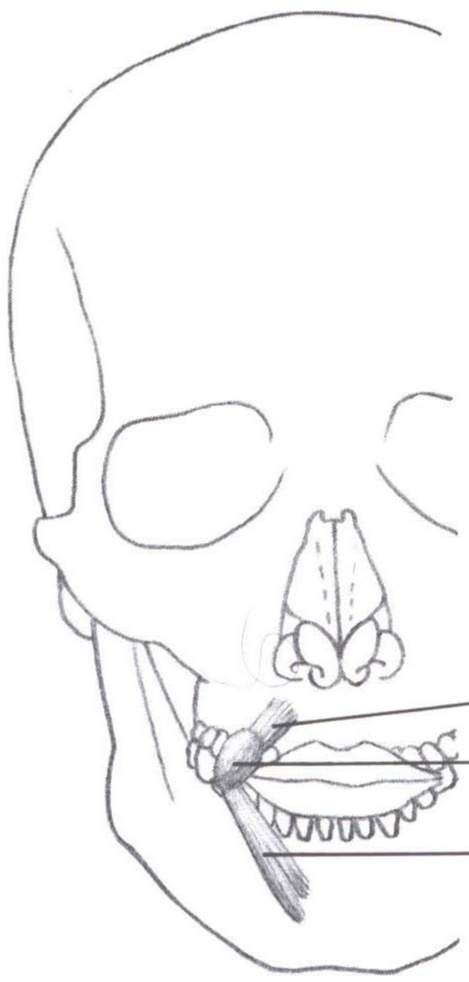
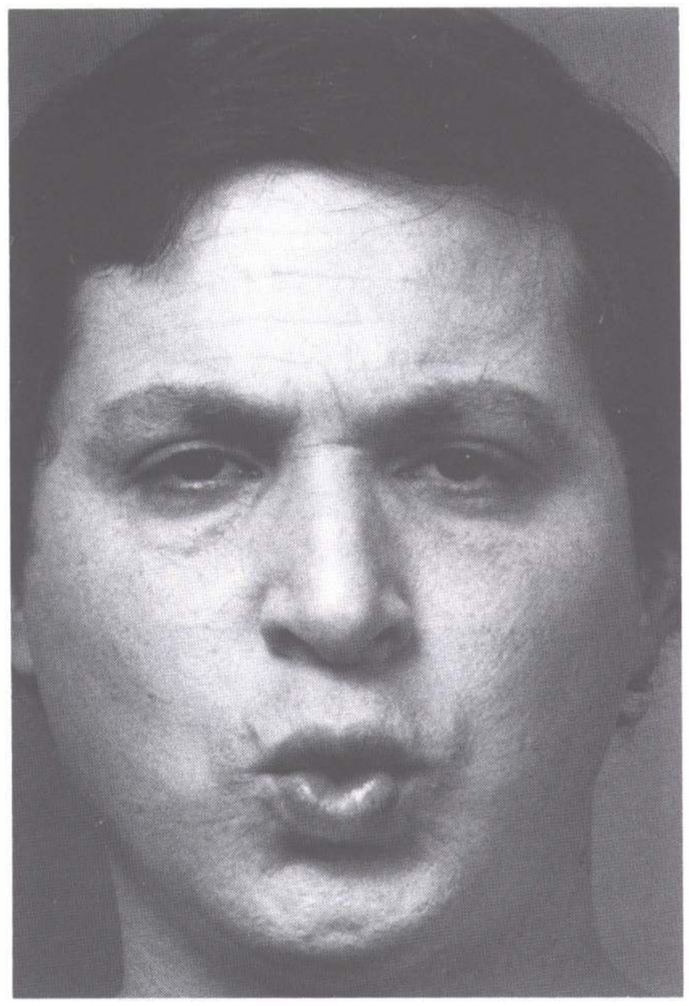
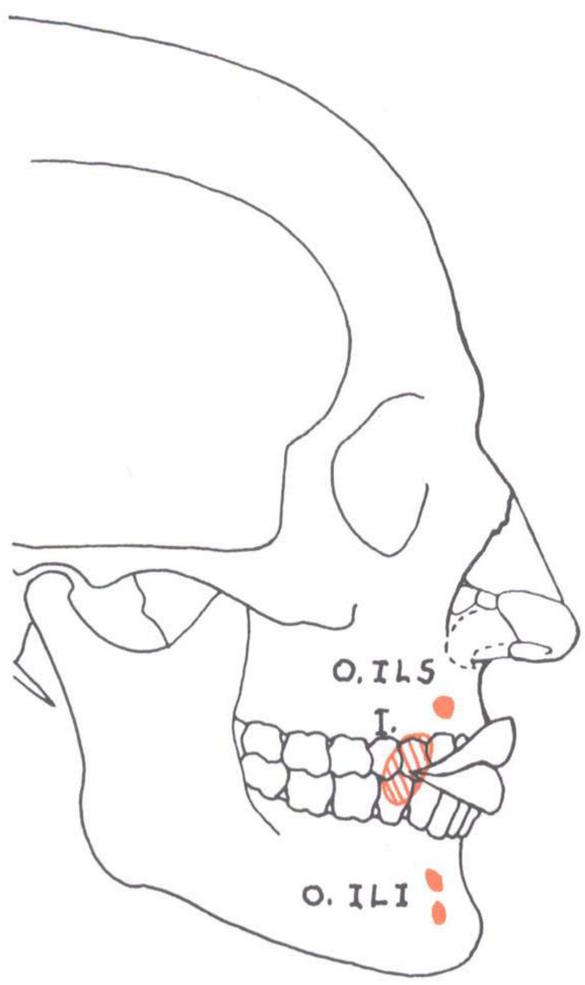
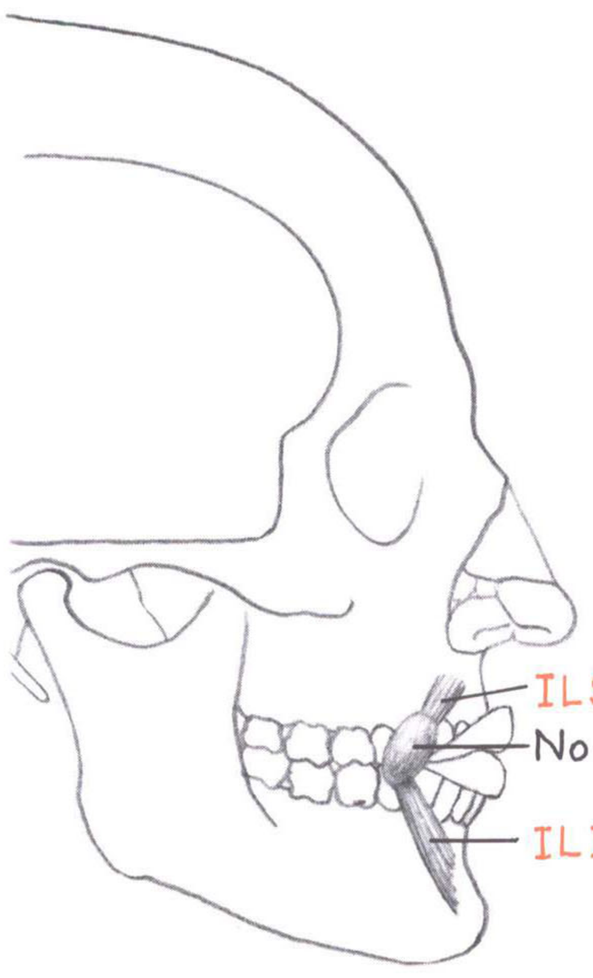
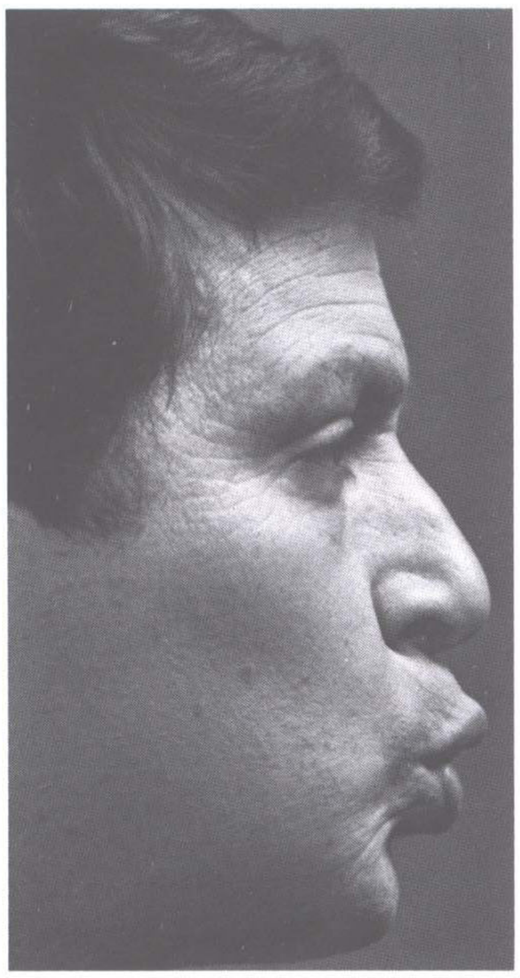












ILI *Incisivus labii inferioris* **ILS** *Incisivus labii superioris* **No** *Node* **OOr** *Orbicularis oris*

Incisivus Labii Superioris and Inferioris

ORIGIN *Superioris:* Two small areas (side by side) on the front of the maxilla above the lateral incisor tooth. *Inferioris:* Two small areas (one above the other) on the front of the mandible, below both incisor teeth, and just lateral to the origin of the mentalis.

INSERTION Both the incisivus labii superioris and inferioris insert into the muscular node at the angle of the mouth—the superioris into the top of the mass of the node, the inferioris into the bottom. Some fibers of the inferioris may insert directly into the skin near the lower edge of the node.

ACTION All four incisivus muscles (from both sides of the face) can act independently in pulling the node obliquely—the superioris pulls the node upward and medially, the inferioris pulls it downward and medially. Usually, all four muscles work together to pull both nodes medially (toward each other), which rounds out the mouth and puckers the lips, i.e., for kissing, whistling, or pronouncing the word "fool." The mouth will remain slightly open unless the outer portions of the orbicularis oris contract. The contraction of the incisivus labii superioris and inferioris of one side of the face pulls only that side's angle of the mouth medially. This places the mouth in the so-called position of "speaking from one side of the mouth."

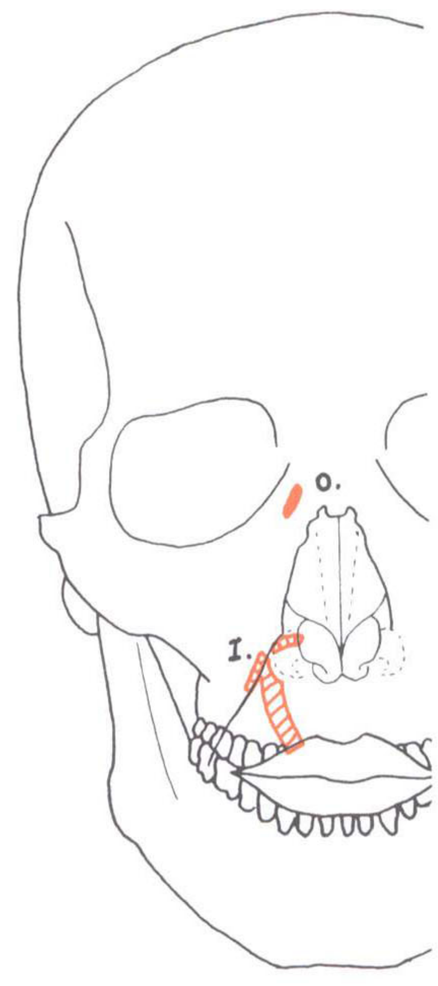
STRUCTURE The incisivus muscles are narrow muscular bands. Together, the incisivus labii superioris and inferioris of one side of the face form a V-shaped muscular sling. This sling is suspended between the upper and lower bony attachments, with its apex attached to the node.

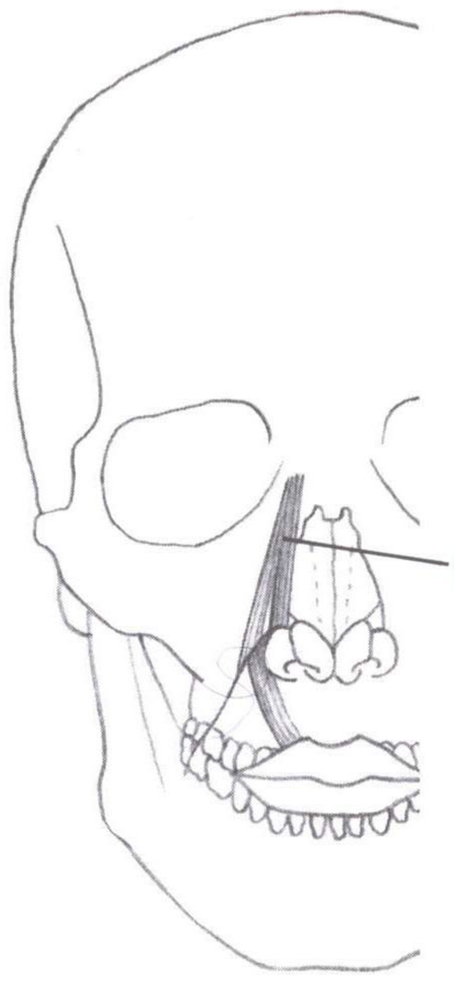
EFFECT Contraction of all the incisivus muscles rounds off the lips and leaves the mouth opening small and circular. They tend to evert, protrude, and thicken the lips slightly. Mild transverse wrinkles develop across the red parts of the lips and create vertical wrinkles in the skin above the upper lip. The red portions of the lips *remain soft;* however, they can be inverted and tightened by the red lip portion of the orbicularis oris with the lips still in their protruded position.

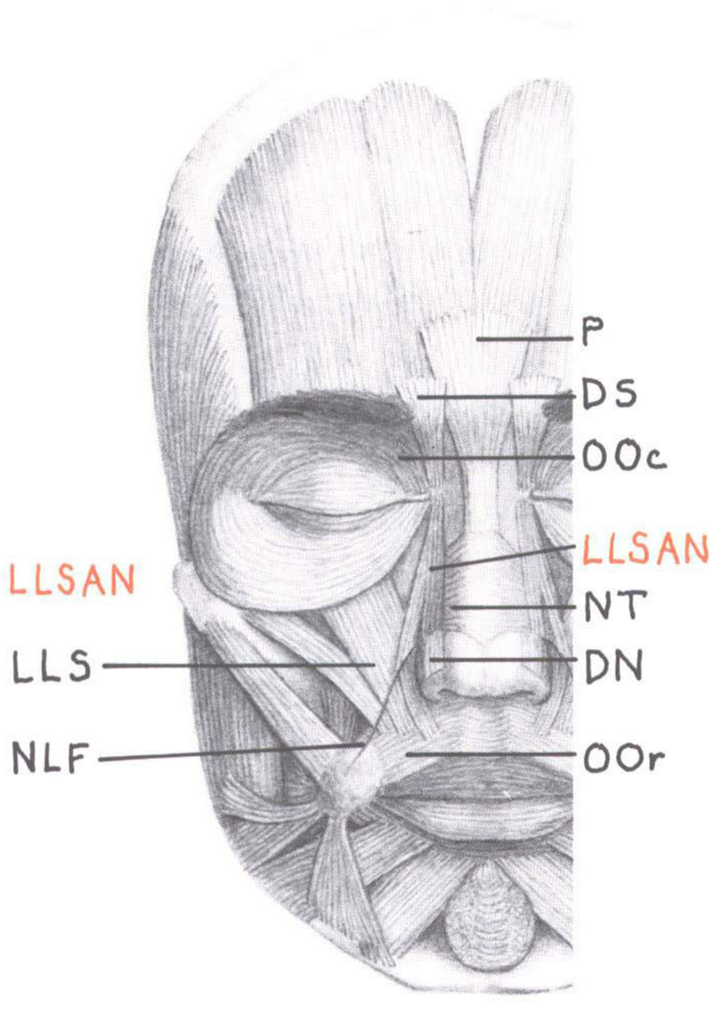
The incisivus muscles pull the lower end of the nasolabial furrow medially and forward, and tend to erase it. They also deepen the philtrum.

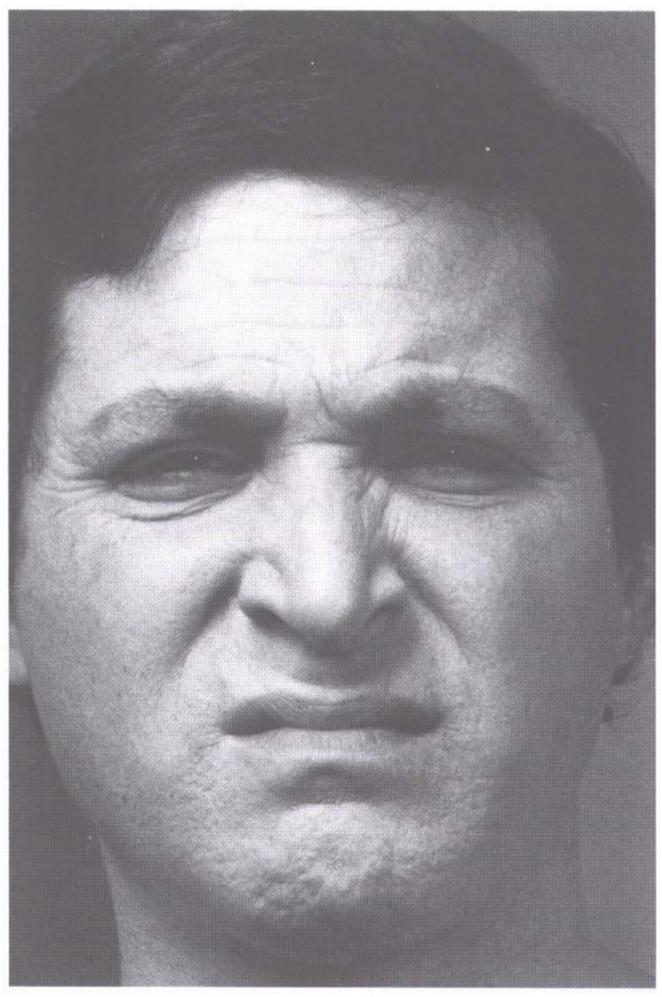
The form of the incisivus labii inferioris may occasionally be seen on the surface during speaking, even though it is covered by fibers of the labial platysma and the depressor labii inferioris. Its cutaneous insertion may produce skin dimpling at the bottom of the node.

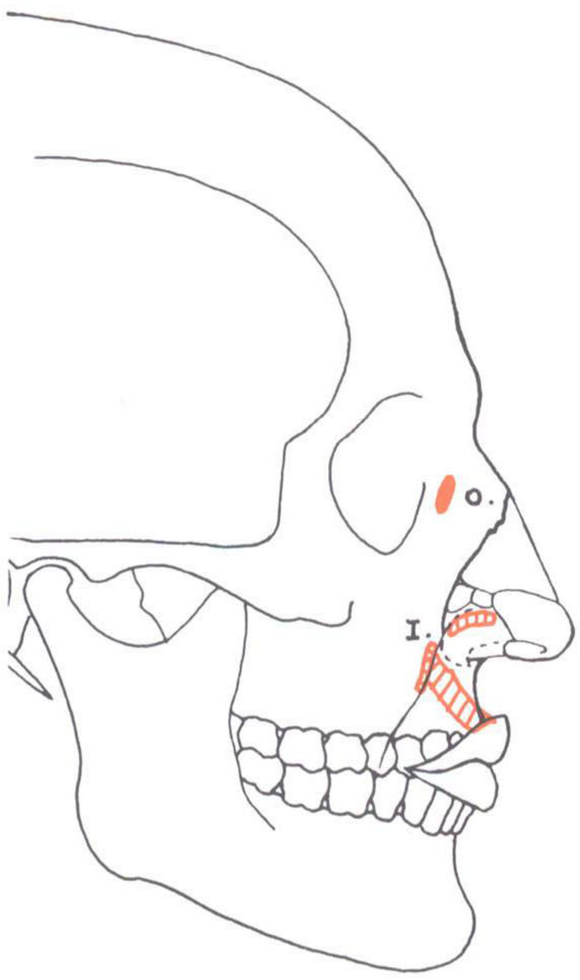
EXPRESSION Placing the lips in the kissing position is an expression of affection and sensual enticement, or in total opposition, provocative insult. Rounding (without puckering) the relaxed lips by the incisivus muscles is one of the "interest" expressions. Bringing the angles of the mouth together and then contracting the orbicularis oris (tensing the red portion and/or pressing the lips together) displays anger.

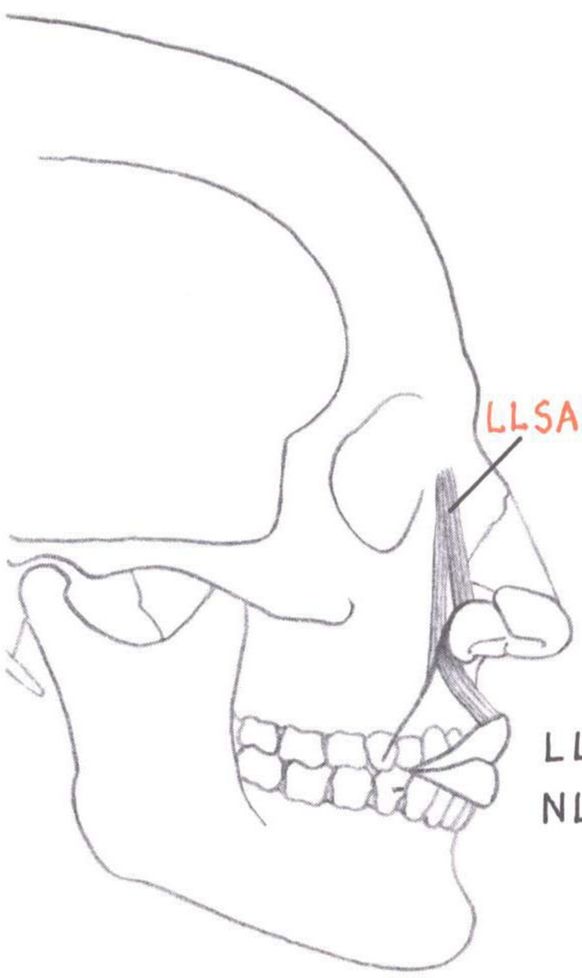


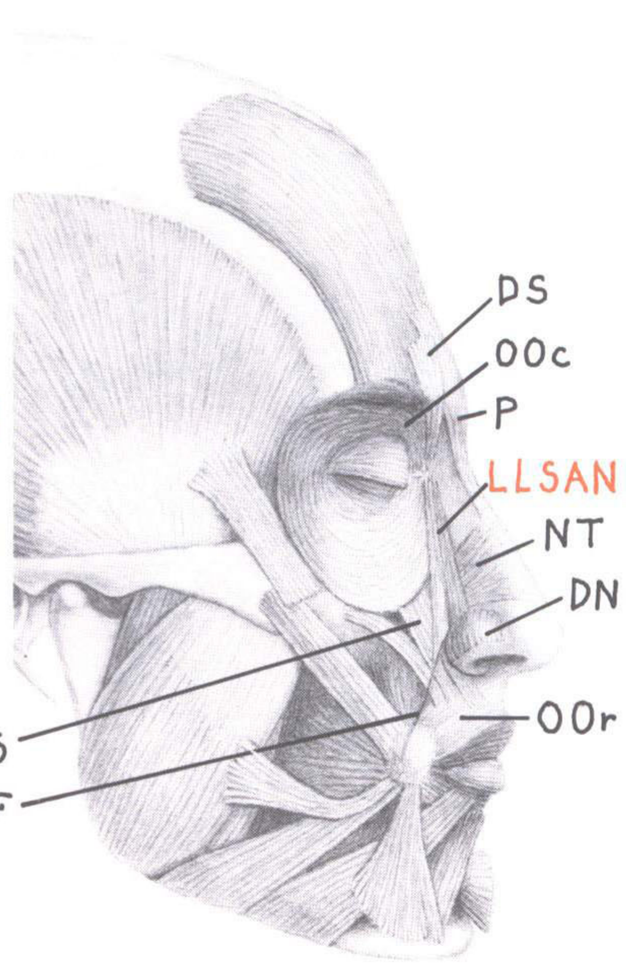


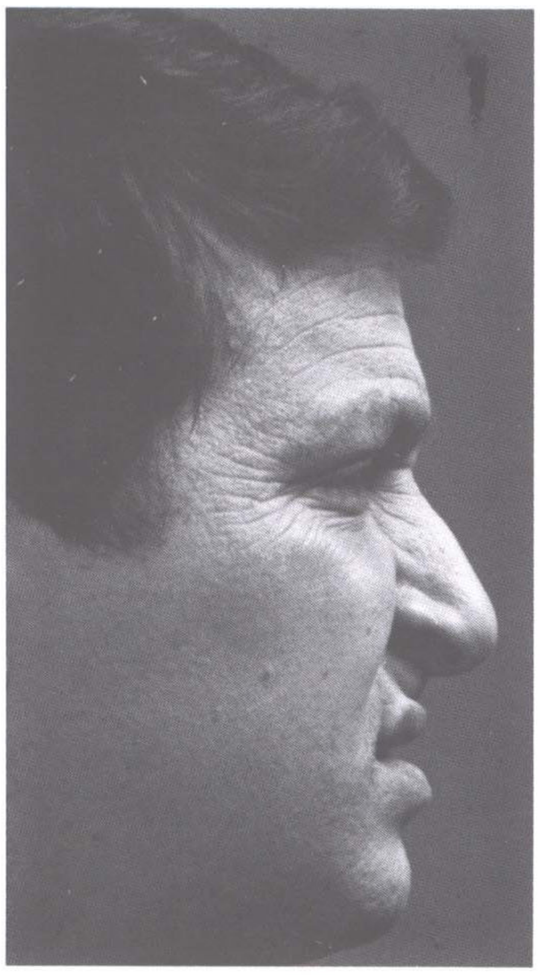












DN *Dilator naris* **DS** *Depressor supercilii* **LLS** *Levator labii superioris*
LLSAN *Levator labii superioris alaeque nasi* **NLF** *Nasolabial furrow* **NT** *Nasalis—transverse part*
OOc *Orbicularis oculi* **OOr** *Orbicularis oris* **P** *Procerus*

Levator Labii Superioris Alaeque Nasi (Quadratus Labii Superioris—Angular Head)

STRUCTURE This slender three-part muscle passes down the side of the nose. It consists of a (nasolabial) **furrow portion,** an **alar portion,** and a **lip portion** (the long portion). The lip portion hooks behind the wing of the nose, then emerges below, descending on the surface of the orbicularis oris. Here it curves medially while continuously inserting into the skin of the upper lip down to the red part, as well as into the ridge of the philtrum. These fibers do not reach the center of the philtrum. The three parts of the levator labii superioris alaeque nasi lie on top of the nasalis muscle. The furrow portion lies partially on top of the levator labii superioris and may extend further laterally onto the surface of the zygomaticus minor.

ORIGIN The side of the bridge of the nose on the superior prolongation of the maxilla, just medial to the inner corner of the eye. The origin is located just above or below the medial palpebral ligament.

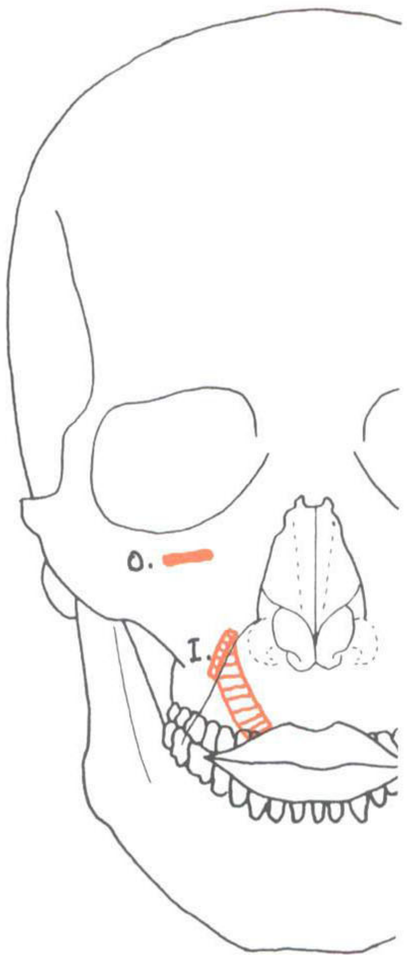
INSERTION Dividing into three slips, the *furrow portion* inserts into the uppermost end of the nasolabial furrow, the *alar portion* inserts into the skin of the posterior end of the wing of the nose, and the *lip portion* inserts continuously into the skin of the upper lip from below the posterior end of the wing of the nose to the lower end of the ridge of the philtrum (up to the red lip margin). Some of the long fibers of the lip portion penetrate the mass of the orbicularis oris in the same manner as the insertion of the neighboring levator labii superioris.

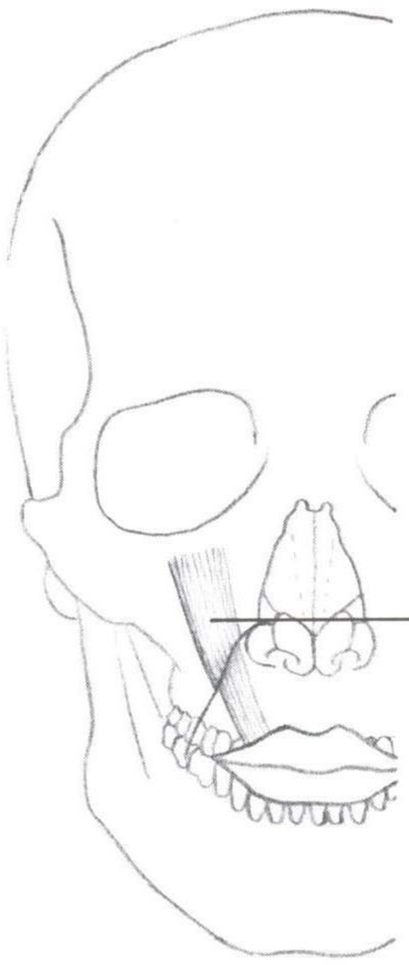
ACTION All three parts contract simultaneously. The levator labii superioris alaeque nasi elevates the upper end of the nasolabial furrow, the posterior end of the wing of the nose, and the middle portion of each side of the upper lip. It only mildly lifts the central (midline) portion of the upper lip. By continued action, it can just about part the lips (by raising the midportion of the upper lip, but only slightly). Both sides usually work simultaneously, but they can contract unilaterally. Some brow and central forehead lowering by the procerus automatically accompanies contraction of the levator labii superioris alaeque nasi. This action pushes the upper eyelid downward.

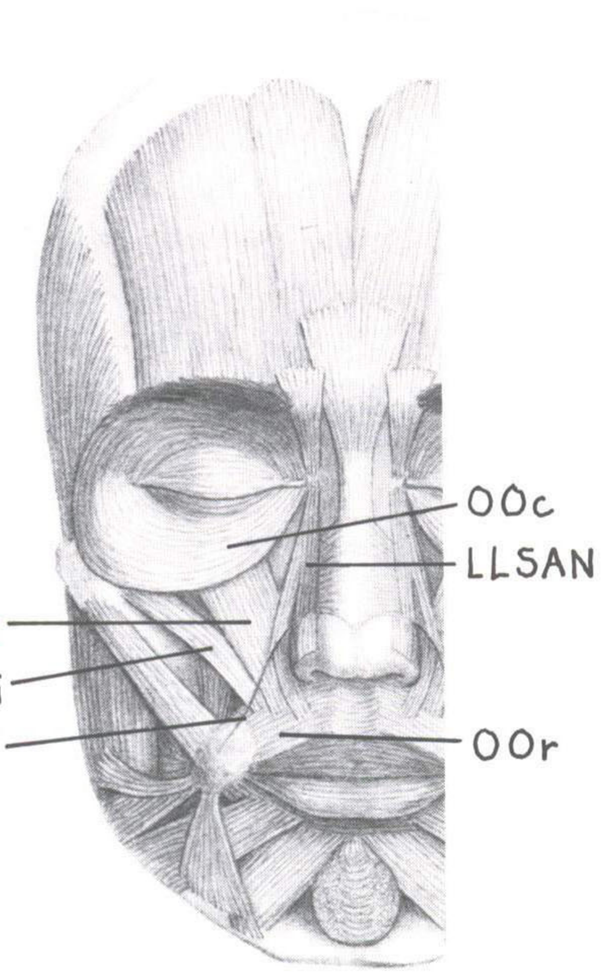
EFFECT The levator labii superioris alaeque nasi creates strong wrinkles on the bridge and side of the nose, raises the skin on the side of the nose, and pulls the front of the cheek upward toward the inner corner of the eye. This movement bulges the front of the cheek as it is pulled upward, strongly deepens the wrinkles under the eye, and pushes the lower eyelid upward. It especially lifts and deepens the upper end of the nasolabial furrow. The eyes become narrowed as the cheek pushes the lower eyelid upward, and the procerus automatically pushes the upper eyelid downward. Raising the wing of the nose makes the nose more pointed at its tip.

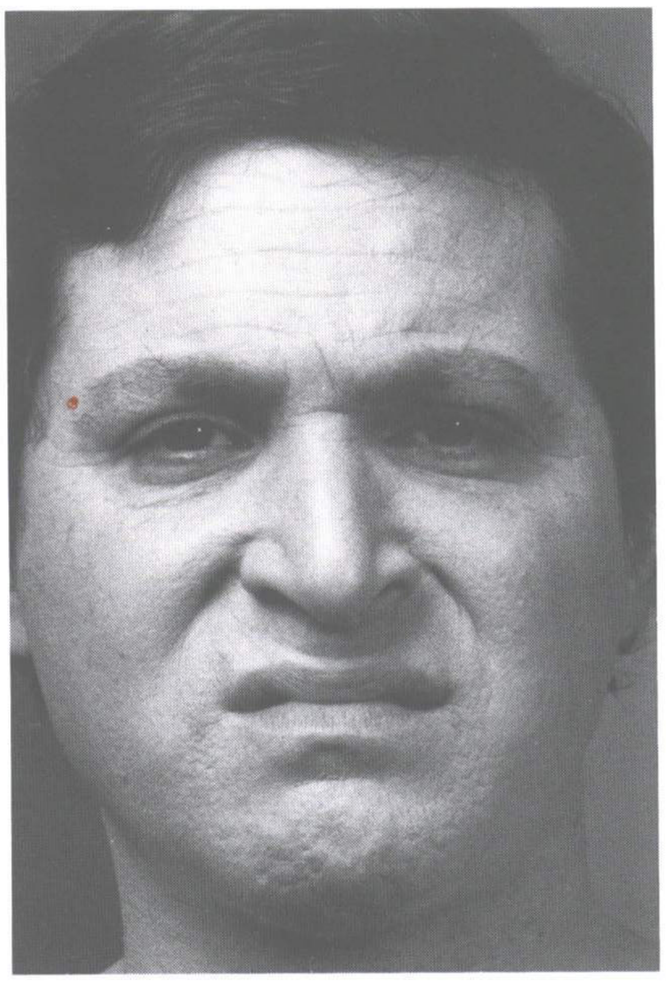
A horizontal crescent-shaped skin fold may develop across the philtrum a short distance above the center of the red portion of the upper lip when both sides contract together. Its ends curve upward.

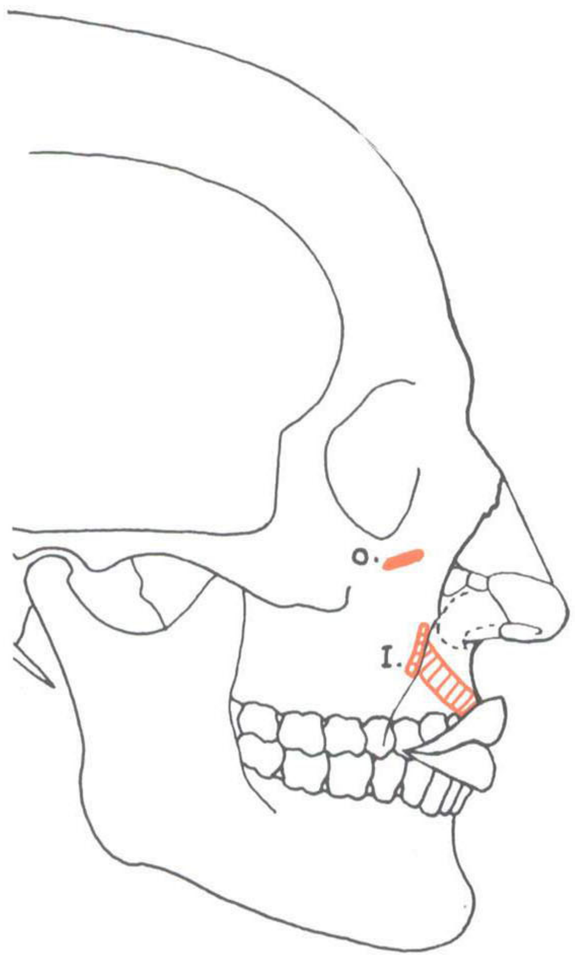
EXPRESSION Disgust, repulsion, disdain, disapproval.

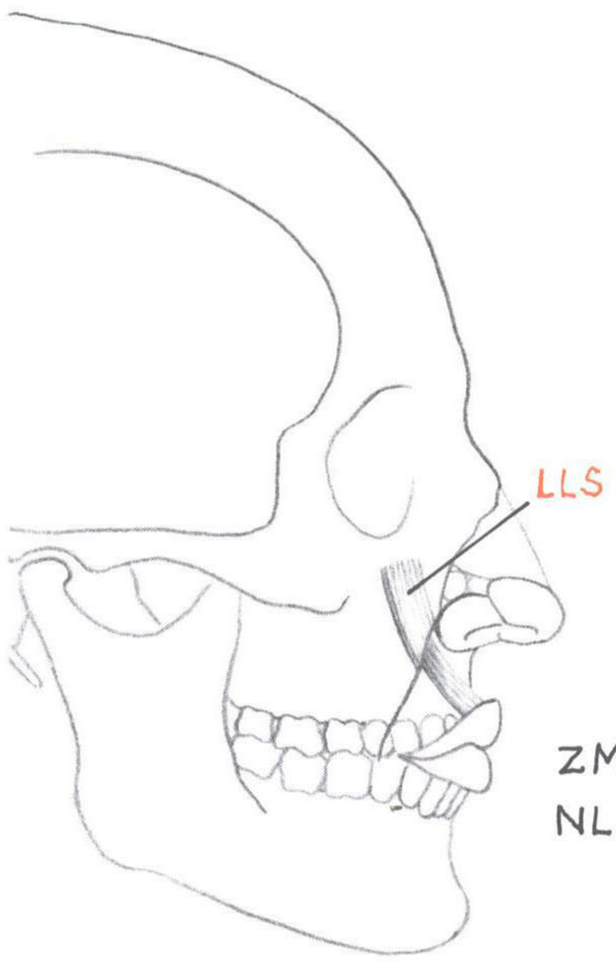


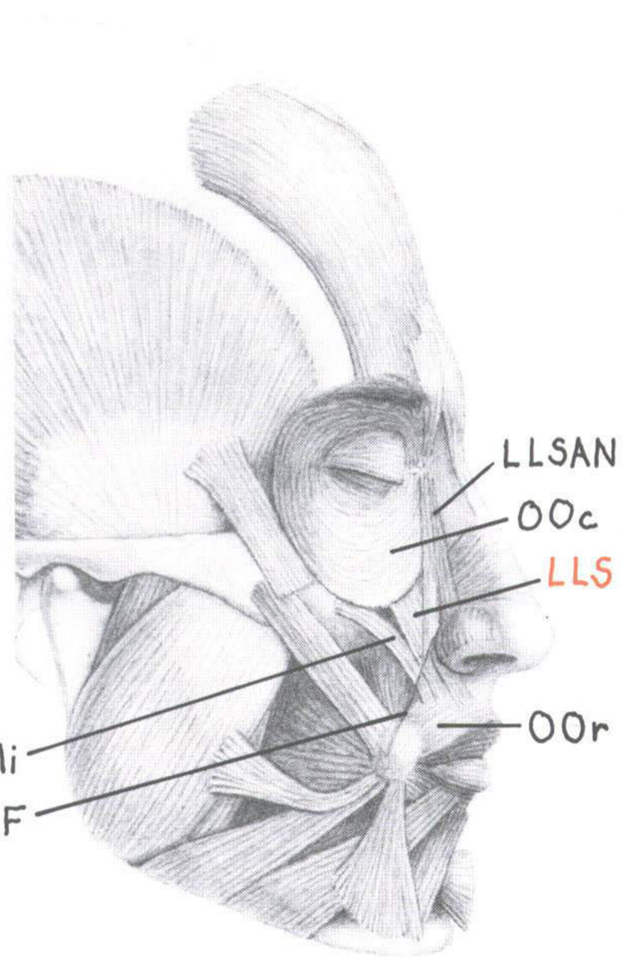


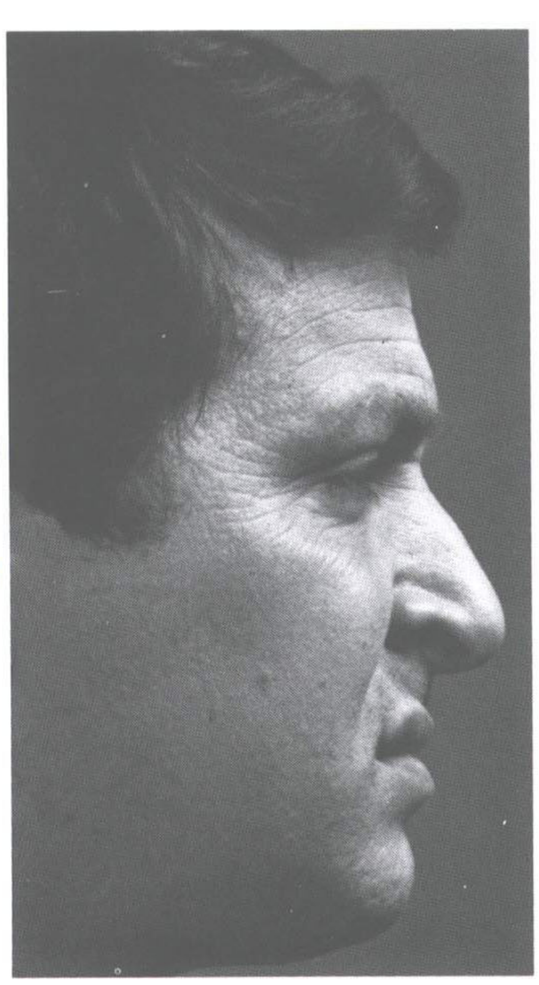




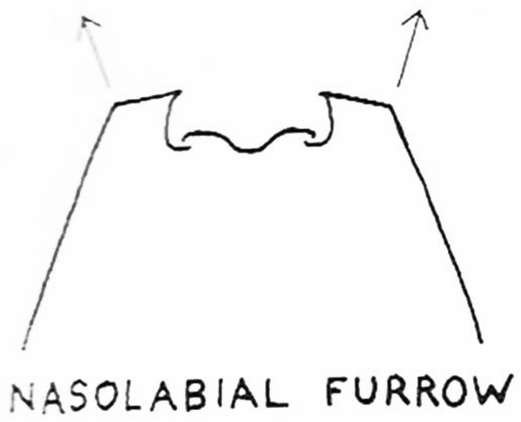








LLS *Levator labii superioris* **LLSAN** *Levator labii superioris alaeque nasi* **NLF** *Nasolabial furrow*
OOc *Orbicularis oculi* **OOr** *Orbicularis oris* **ZMi** *Zygomaticus minor*



Levator Labii Superioris (Quadratus Labii Superioris—Infraorbital Head)

ORIGIN A long, thin line on the lower border of the orbit, from both the maxilla and zygomatic bone.

INSERTION *Superficial fibers:* The skin of the nasolabial furrow, just lateral to the wing of the nose. Other fibers pass downward beyond the furrow, continuously inserting into the deep surface of the skin of the upper lip, up to the red lip portion. *Middle fibers:* The next layer proceeds downward just beneath and parallel to the superficial layer, passes between the red lip and outer parts of the orbicularis oris, and inserts on the inside of the lip where the dry red part of the lip meets the moist mucous membrane, as well as into the red part itself. *Deep fibers:* This layer penetrates the bulk of the outer part of the orbicularis and inserts at numerous points into the mucous membrane on the inside of the mouth.

ACTION Raises the center of each half of the upper lip, producing the typical sneer. By continued action it parts the lips at the same spot (it doesn't lift the center of the upper lip). It assists in eversion of the upper lip if the outer part of the orbicularis oris is contracted.

STRUCTURE The levator labii superioris, forming part of the upper labial tractor, is a relatively wide, quadrilateral muscle layer that thins as it descends. It consists of three layers—superficial, middle, and deep. The muscle originates deep to the lower edge of the orbicularis oculi and gains its various insertions into the upper lip region between the levator labii superioris alaeque nasi and the zygomaticus minor. Sometimes it lies on a deeper plane than these two muscles and is then partially covered by them.

EFFECT The levator labii superioris pulls the upper portion of the nasolabial furrow upward and outward, squaring its line as well as deepening it. This is characteristic of the muscle. The front of the cheek above the nasolabial furrow rises and bulges. Lines and wrinkles below the eye develop or deepen. Both sides contracting together square-off the upper lip. If the lips are parted by the levator labii superioris, the upper gum (and usually the upper portion of the upper front teeth) becomes exposed. It also pulls the posterior end of the wing of the nose outward and upward, widening the nostril. The long fibers of this muscle that pass down the surface of the orbicularis oris to the red part of the lip can be seen as an oblique relief form on the surface, passing downward and medially just lateral to the wing of the nose, when the lips are pressed together. *The levator labii superioris does not produce wrinkles on the side of the nose.* A horizontal crescent-shaped skin fold may develop across the philtrum a short distance above the center portion of the red portion of the upper lip when both sides contract together. Its ends curve upward.

EXPRESSION Disgust, retching (vomiting), disdain, contempt.

Zygomaticus Minor (Quadratus Labii Superioris—Zygomatic Head)

ORIGIN The front surface of the zygomatic bone, below the lateral edge of the orbit (below the outer corner of the eye).

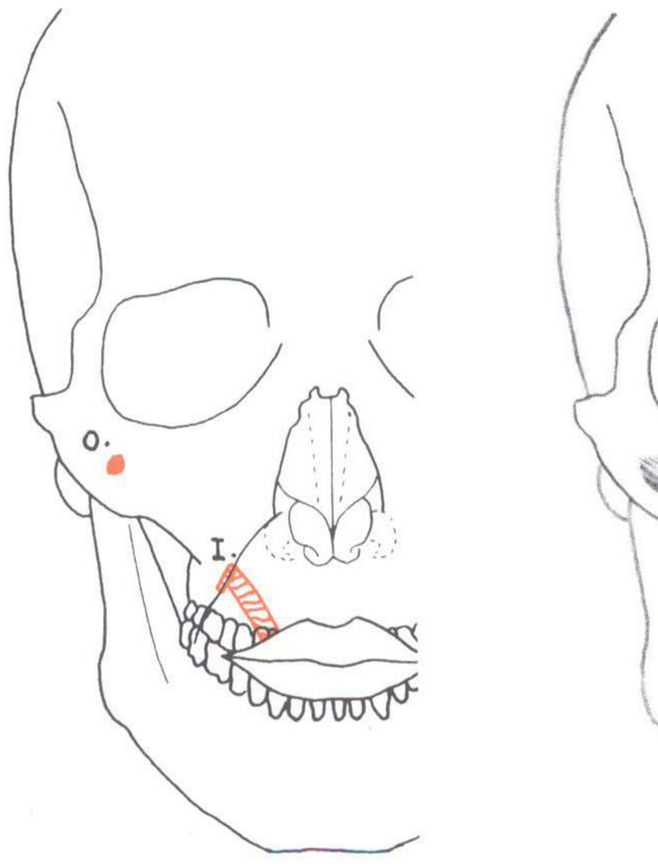
INSERTION The skin of the middle section of the nasolabial furrow and into the cheek fat. Other fibers continue further downward to the red lip, passing over as well as through the mass of the orbicularis oris (see insertion of levator labii superioris).

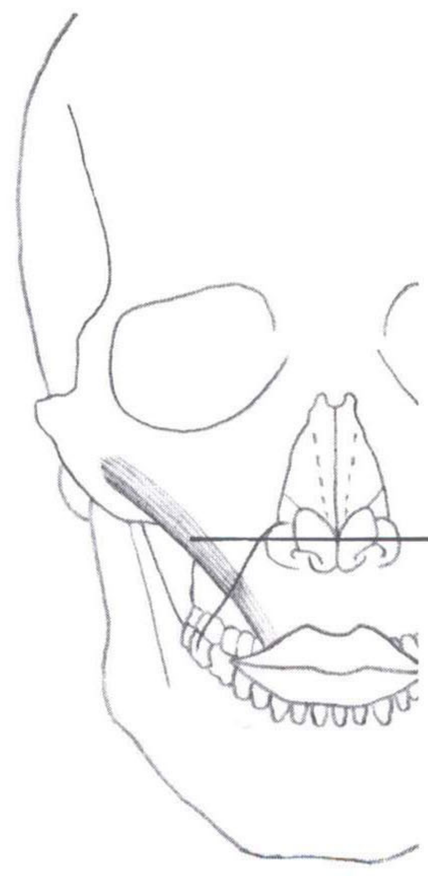
ACTION Pulls the middle section of the nasolabial furrow and the middle portion of one side of the upper lip outward and slightly upward. This is a subtle, oblique pull, whereas the pull of the levator labii superioris is straight up. The zygomaticus minor does not pull the angle of the mouth.

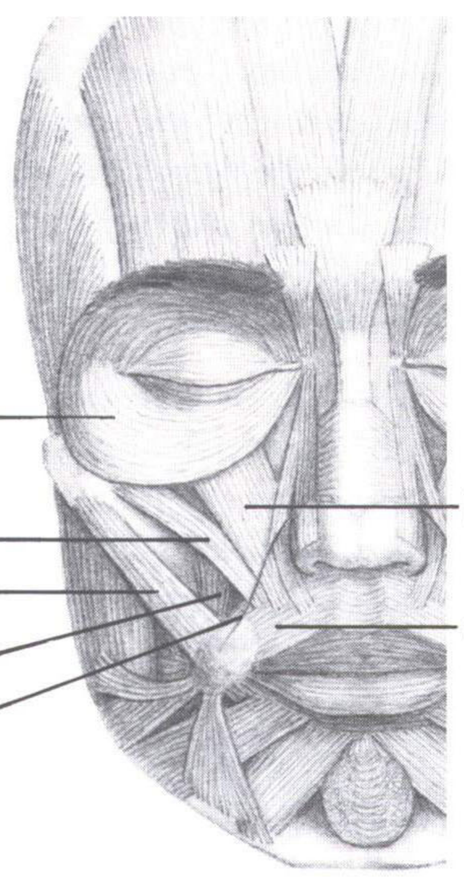
STRUCTURE From its origin, this small muscle passes medially and then curves downward. It lies deep to the orbicularis oculi at its origin.

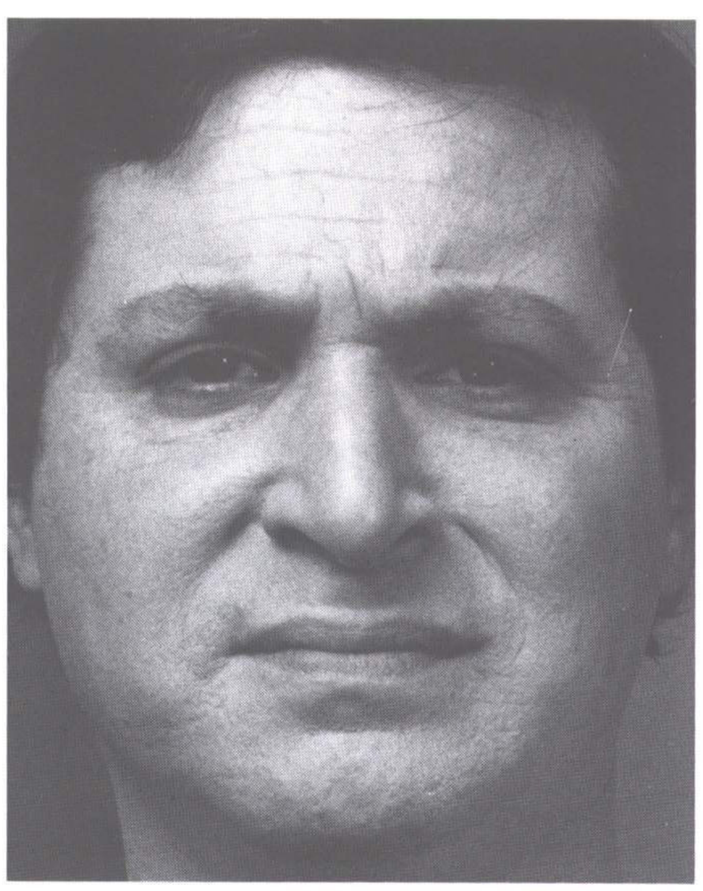
EFFECT The zygomaticus minor deepens the portion of the middle section of the nasolabial furrow located midway between the level of the bottom of the nose and the top of the upper lip.

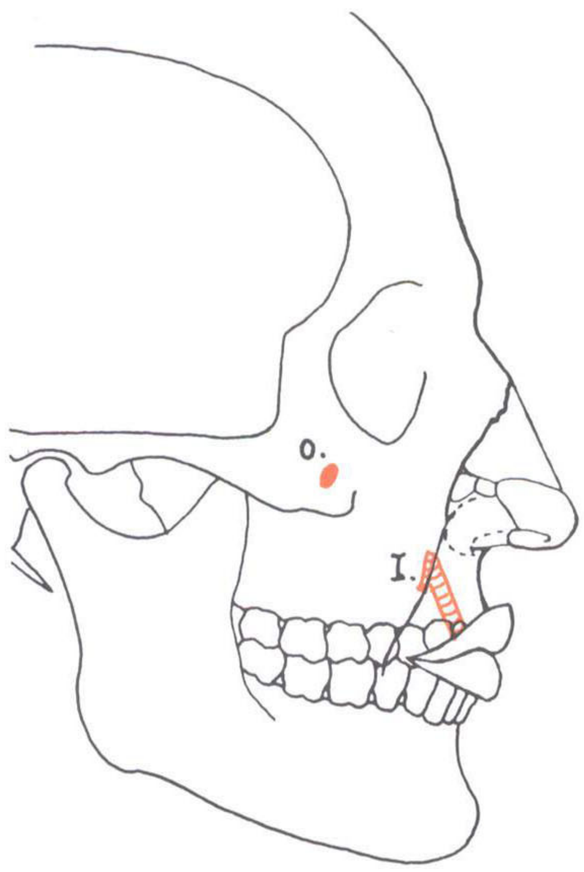
EXPRESSION Sadness. It pulls the upper lip into the crying position. The zygomaticus minor does not express disgust or happiness, although its action may look similar to disgust.

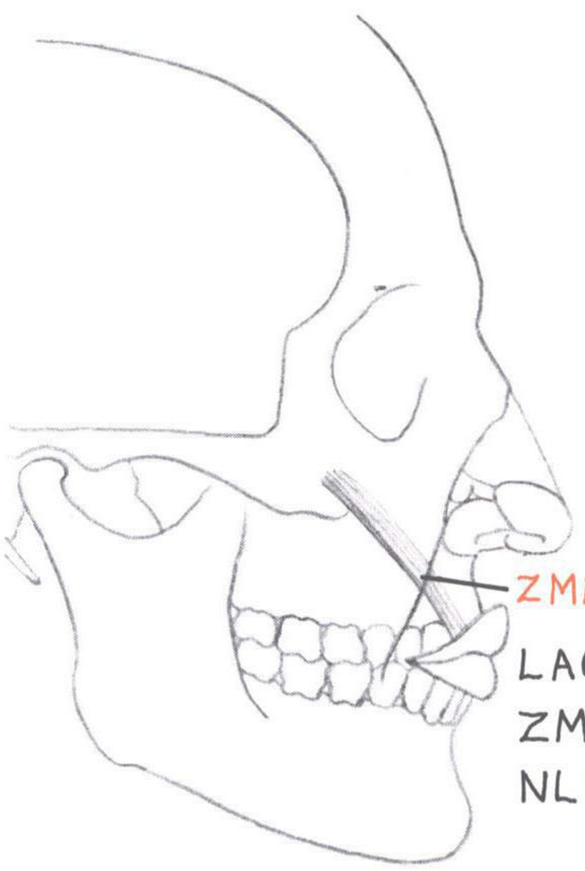


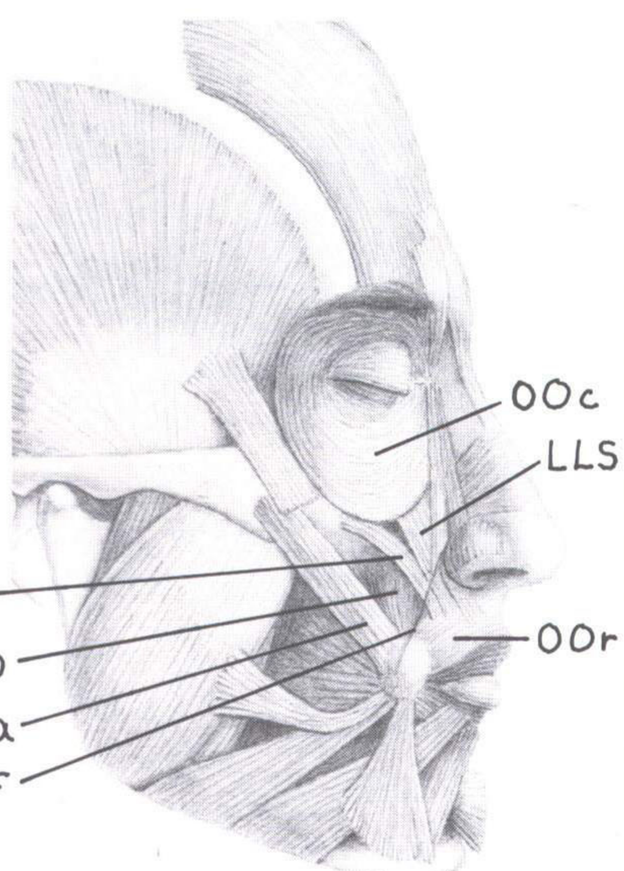


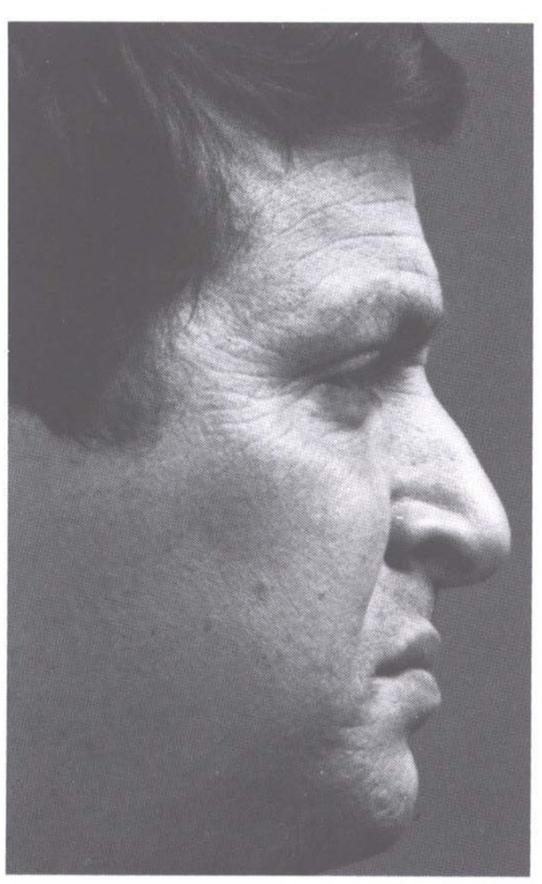












LAO *Levator anguli oris* **LLS** *Levator labii superioris* **NLF** *Nasolabial furrow* **No** *Node*

Levator Anguli Oris (Caninus)

ORIGIN The canine fossa of the maxilla, below the middle of the lower edge of the orbit.

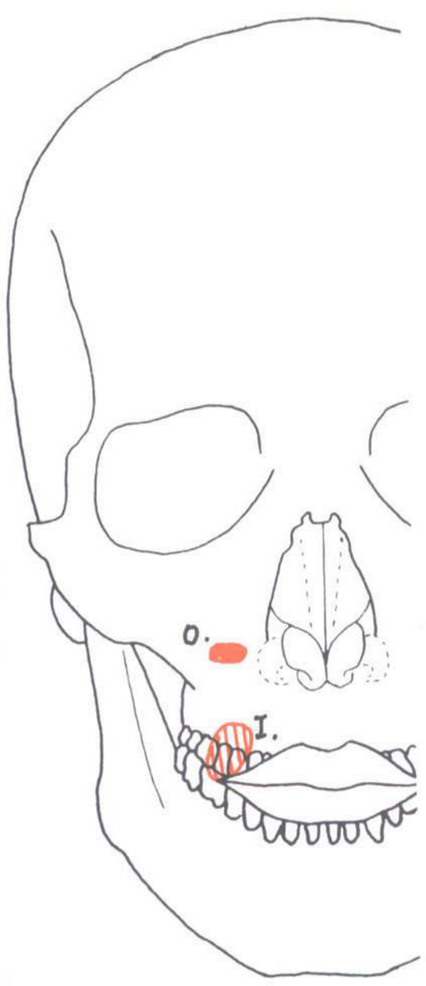
INSERTION The muscular node at the angle of the mouth.

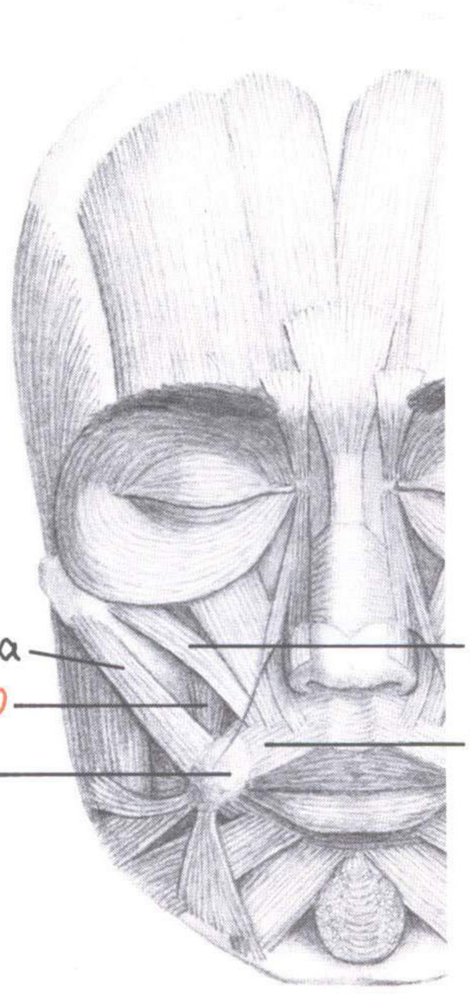
ACTION Pulls the node, and therefore the angle of the mouth (not the upper lip), straight up. This is a difficult action to do voluntarily.

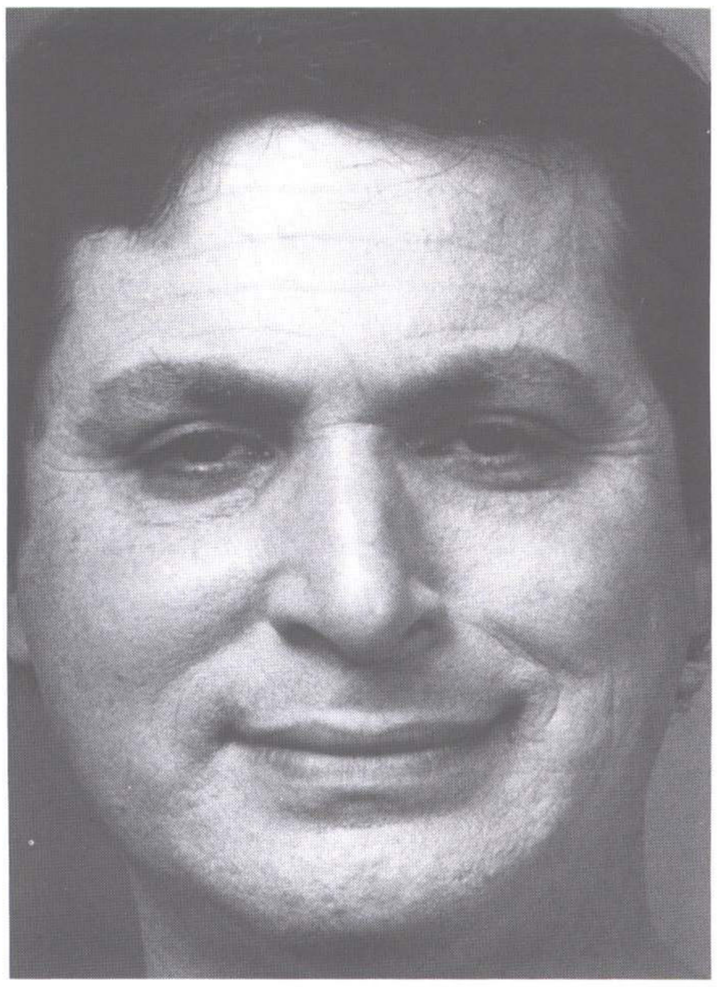
STRUCTURE This somewhat fan-shaped muscle converges inferiorly into the node. It lies deep to other facial muscles.

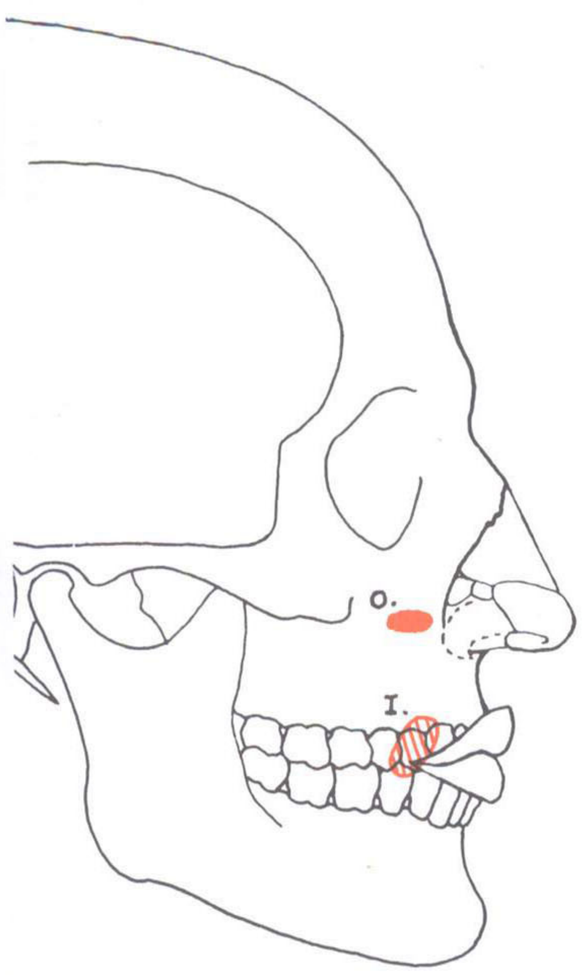
EFFECT Pulling the angles of the mouth straight up, the levator anguli oris curves the mouth line upward at its ends. This is a rounder, tighter curvature than that caused by the zygomaticus major during a normal, true smile. The levator anguli oris also stretches the lips. The front of the cheek is lifted and puffed out. The nasolabial furrow rises and moves laterally.

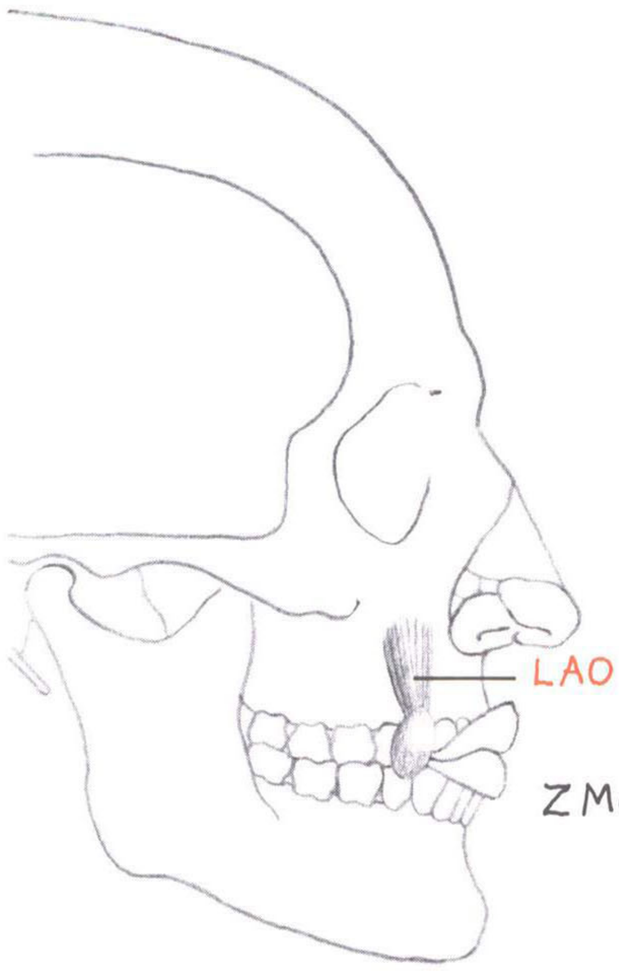
EXPRESSION Uncomfortable, uncertain, or "stupid" smile. This muscle is probably not used in expressing the basic emotions; it may be used primarily to stabilize the node.

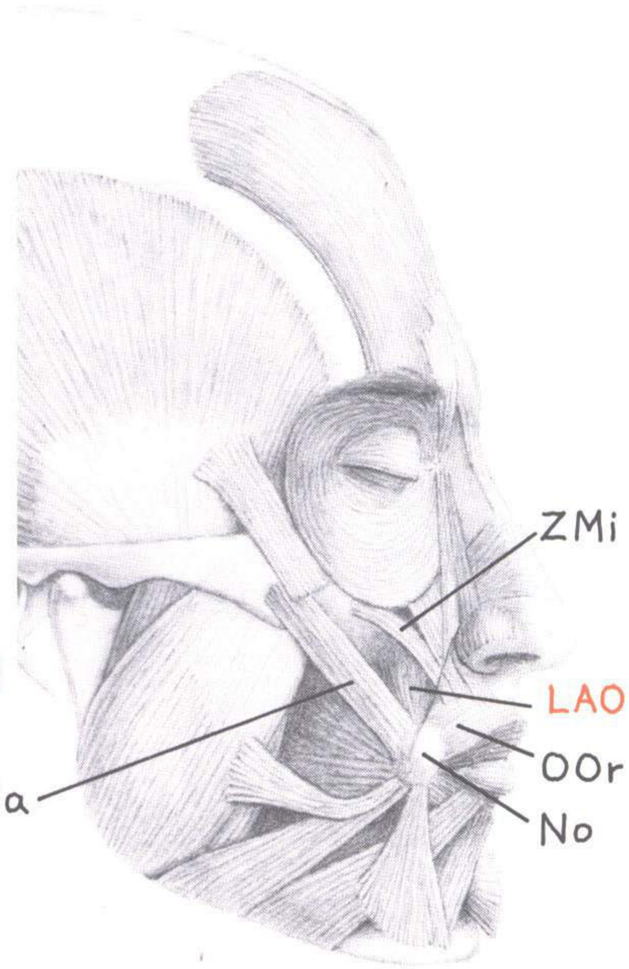


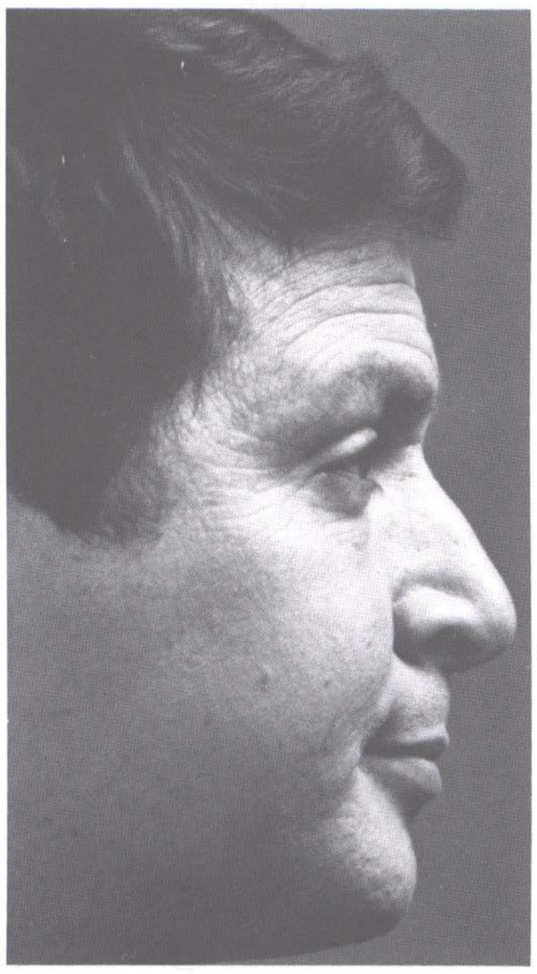




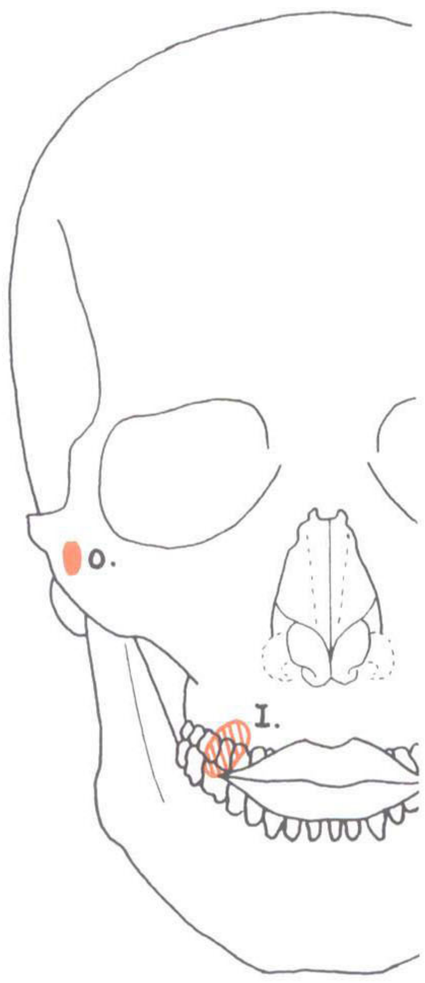


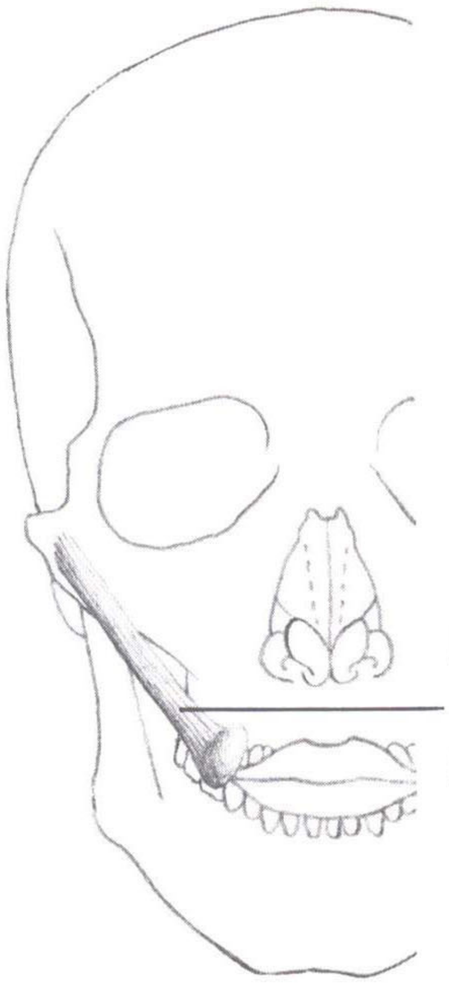


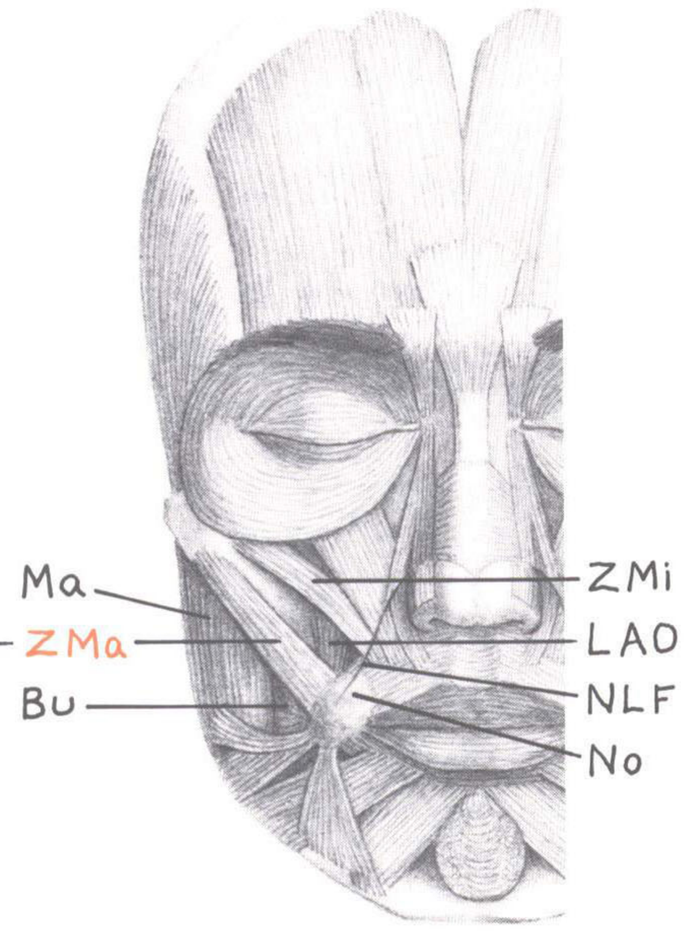


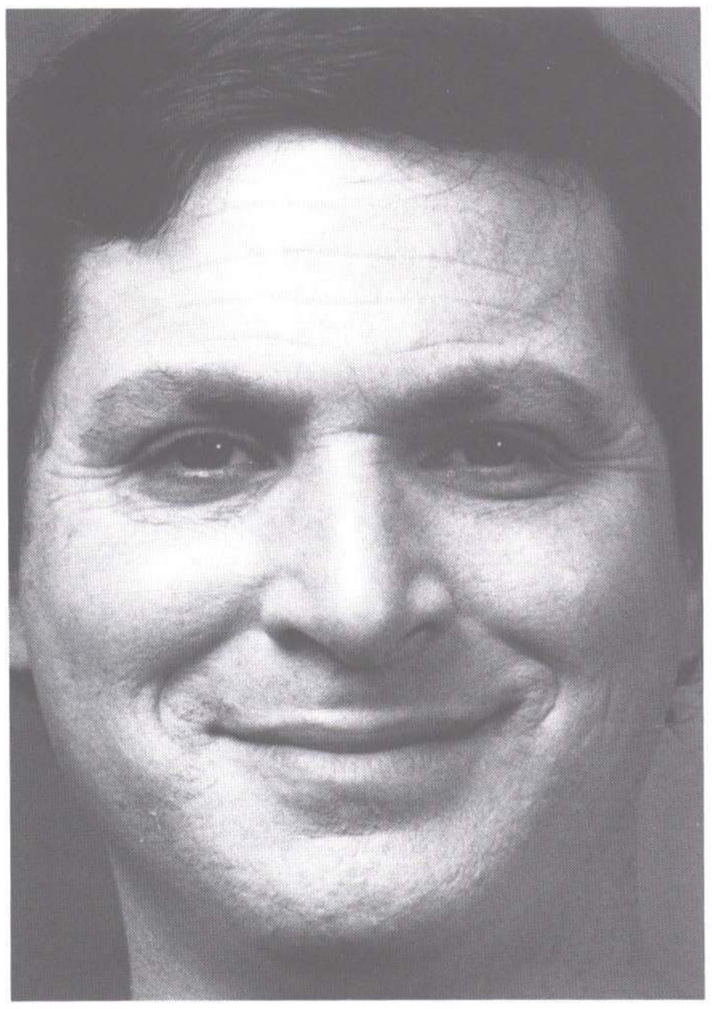


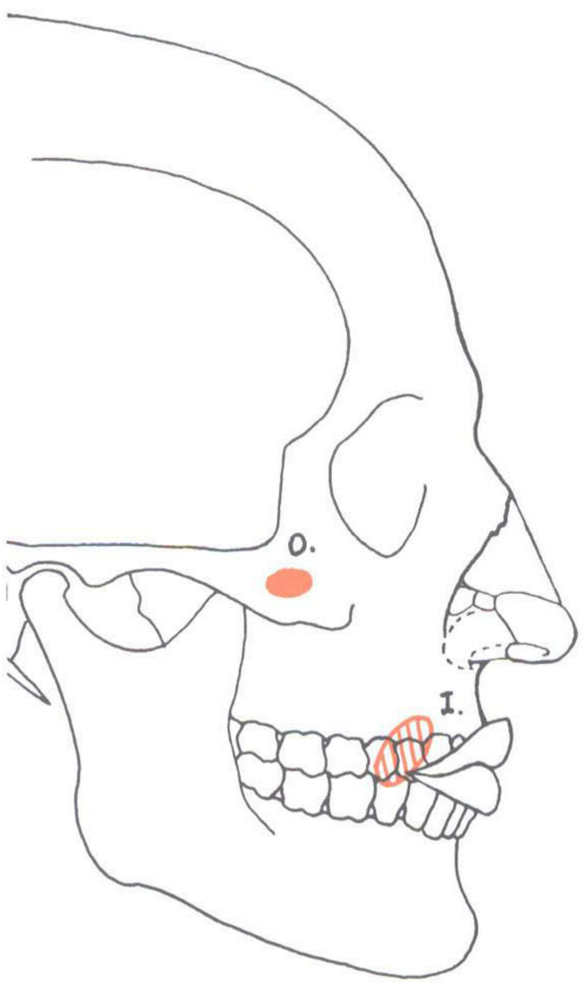
OOc *Orbicularis oculi* **OOr** *Orbicularis oris* **ZMa** *Zygomaticus major* **ZMi** *Zygomaticus minor*

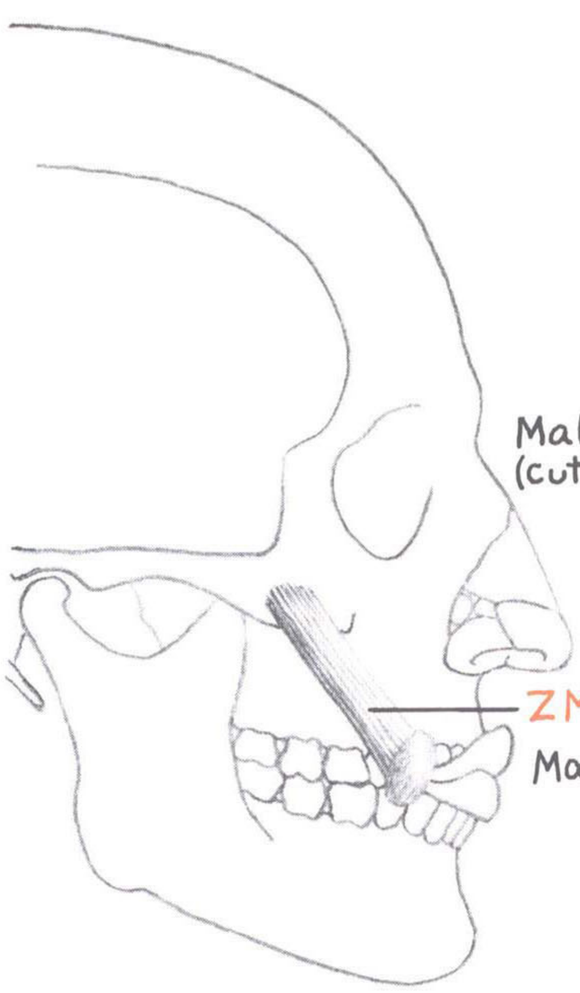


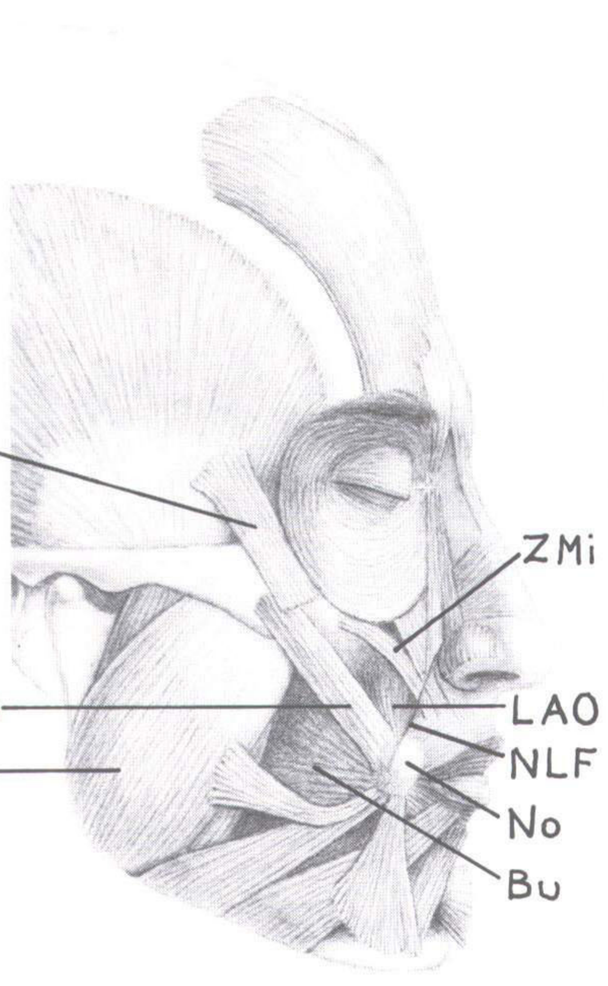


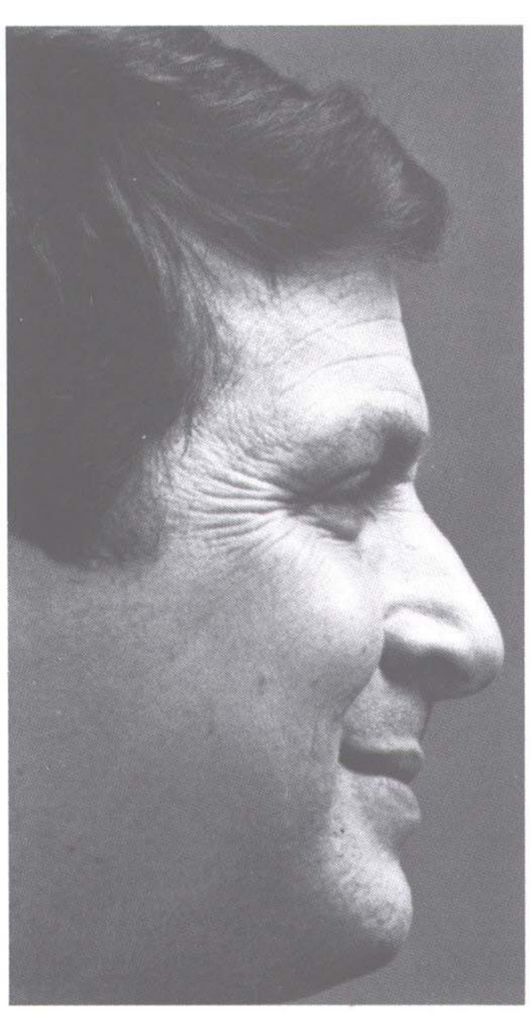












Bu *Buccinator* **LAO** *Levator anguli oris* **Ma** *Masseter* **Mal** *Malaris* **NLF** *Nasolabial furrow*
No *Node* **ZMa** *Zygomaticus major* **ZMi** *Zygomaticus minor*

Zygomaticus Major

ORIGIN A small area on the outside of the zygomatic bone, posterior to the bony outer bar of the eye socket.

INSERTION The muscular node at the angle of the mouth. Some inserting fibers may blend with the risorius or the depressor anguli oris near the node. There are occasional insertions into the skin of the lower end of the nasolabial furrow.

ACTION Pulls the node and therefore the angle of the mouth upward, outward, and backward. The nasolabial furrow and the cheek (not the node) are pulled upward by the malaris (which lies partially on top of the zygomaticus major), not directly by the zygomaticus major.

STRUCTURE The zygomaticus major is a long, narrow muscular band. Because of its length, extensive excursion of the node (and angle of the mouth) is possible. The zygomaticus major splits into superficial and deep portions as it reaches its insertion. The superficial portion often splits into two narrow bellies. These splits do not have any obvious functional significance.

EFFECT The zygomaticus major pulls the overall lower face outward and upward. The entire cheek rises and bulges. The lower eyelid is pushed up slightly onto the iris. The wrinkles under the eye deepen, and crow's feet develop at the outer corner of the eye. The orbicularis oculi contributes to these effects because it often contracts during strong contraction of the zygomaticus major.

The entire nasolabial furrow deepens, especially its lower half, as it is pulled outward, upward, and backward. Pulling the node laterally and upward gathers the tissue lateral to the node into vertical lines and ridges.

The mouth line curves upward at its outer end. The philtrum becomes shallower. The lips are stretched and flattened, and the fleshy prominence of the chin is widened and flattened. The nostrils are widened as the posterior ends of the wings of the nose are pulled outward and raised. The distance between the mouth and the nose decreases.

A **dimple** often appears when smiling. The cause of a dimple may be that an area of the cheek devoid of cheek fat, which is already adhering to the fascia of the zygomaticus, is pulled deeper when that muscle contracts. This depression is accentuated by the bulging of the surrounding bunched cheek fat. It is uncertain if any fibers of the zygomaticus actually insert into the skin of the dimple. It is possible that either originating or inserting fibers of the risorius that insert directly into the skin may cause a dimple. The risorius possibly contracts along with the more powerful zygomaticus major when smiling. The malaris, another smiling muscle, may also send fibers into the skin of the dimple.

EXPRESSION Happiness, joy—smiling and laughing.

Risorius

ORIGIN The fascia of the cheek overlying the masseter muscle (a nonbony origin).

INSERTION The muscular node at the angle of the mouth and sometimes into the posterior edge of the upper end of the depressor anguli oris.

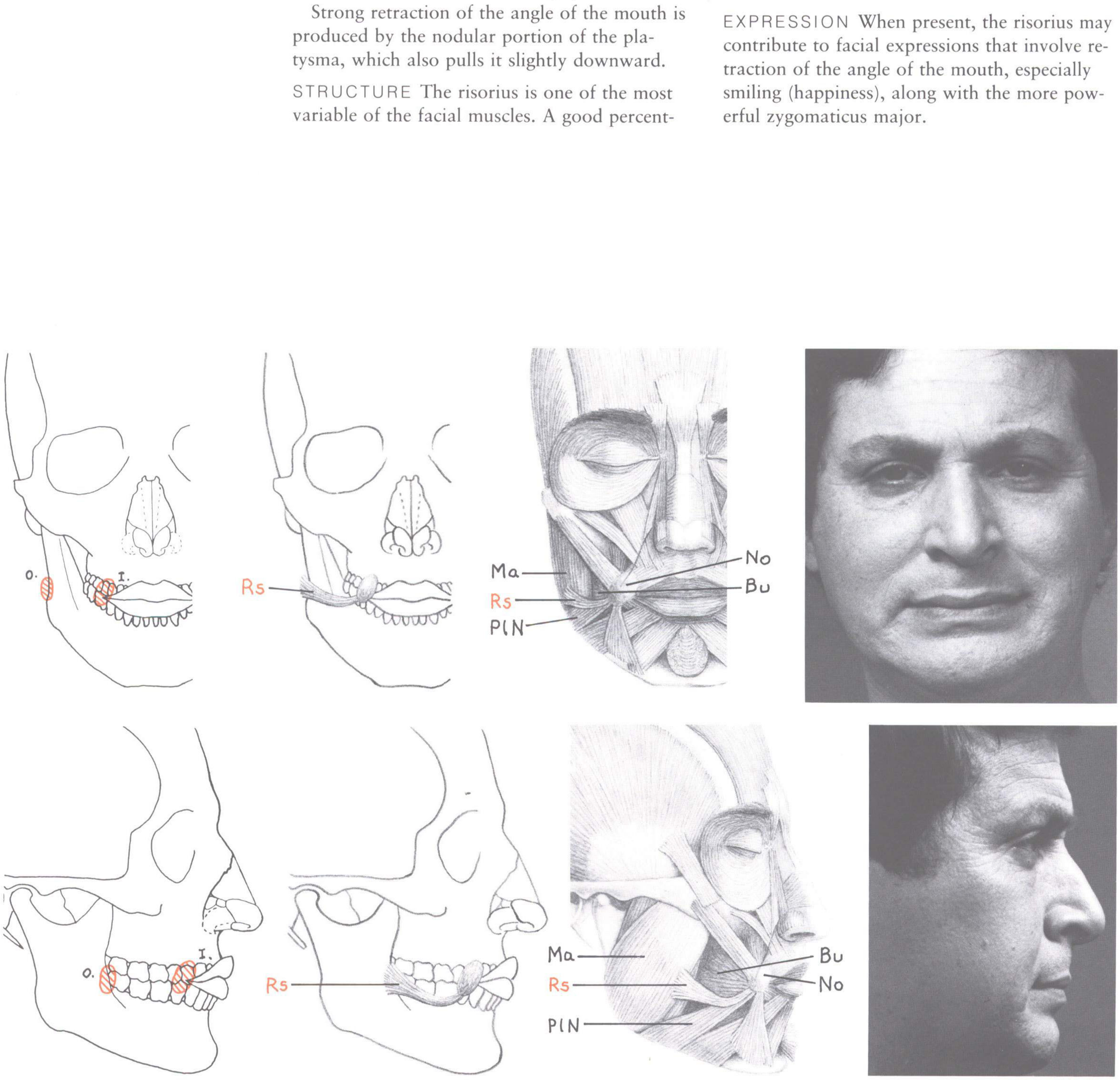
ACTION Pulls the node, and therefore the angle of the mouth, backward and outward—*horizontally*—toward the ear lobe. This very weak action is probably used for creating subtle movements of the mouth during speech.

Strong retraction of the angle of the mouth is produced by the nodular portion of the platysma, which also pulls it slightly downward.

STRUCTURE The risorius is one of the most variable of the facial muscles. A good percentage of people have no risorius at all, while others have an expansive one. In some individuals, the muscle is present on one side of the face only. The nodular platysma, however, is present in all people. Structurally, the risorius ranges from a triangular muscular sheet that converges into the node to a narrow band that may contain only a few strands of muscular fiber.

EFFECT The risorius widens the mouth, stretching and flattening the lips. It pulls the lower end of the nasolabial furrow outward and backward.

EXPRESSION When present, the risorius may contribute to facial expressions that involve retraction of the angle of the mouth, especially smiling (happiness), along with the more powerful zygomaticus major.



Bu *Buccinator* **Ma** *Masseter* **No** *Node* **PlN** *Platysma—nodular portion* **Rs** *Risorius*

Buccinator

ORIGIN The outer surfaces of the upper and lower jaws, just above and below the three back molars respectively, and from a tendinous band that spans across the posterior end of these bony origins.

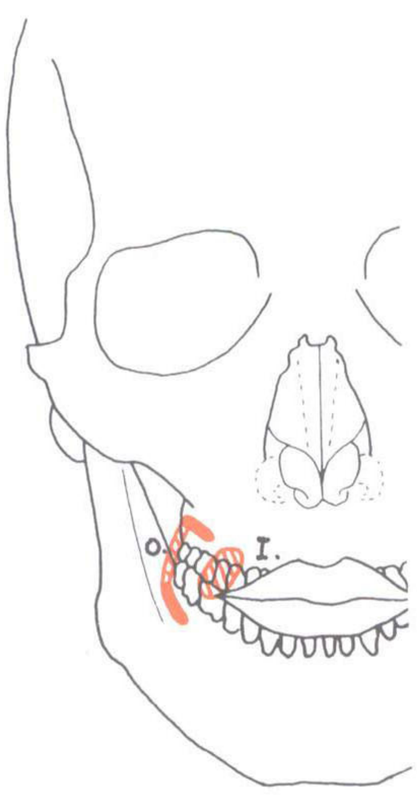
INSERTION Into the muscular node at the angle of the mouth.

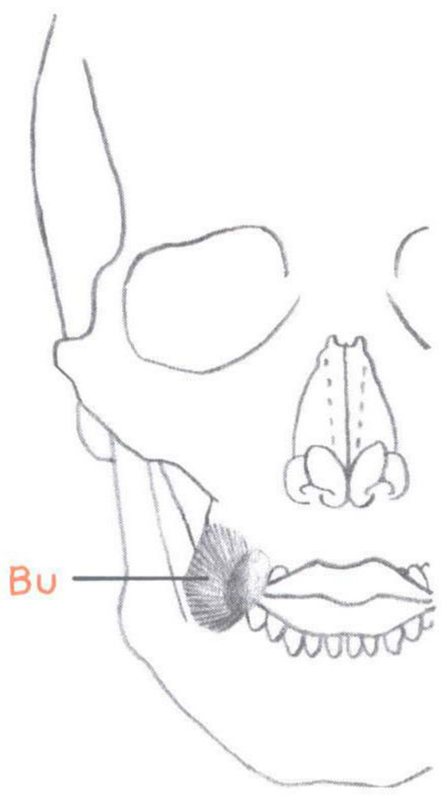
ACTION The buccinator pulls the *medial* edge of the node and the angle of the mouth (the extreme lateral end of the mouth line) *straight back* (posteriorly, not laterally), and usually slightly upward. It compresses the cheeks to force out air after they have been distended (or prevents them from being distended) and keeps food between the teeth while chewing.

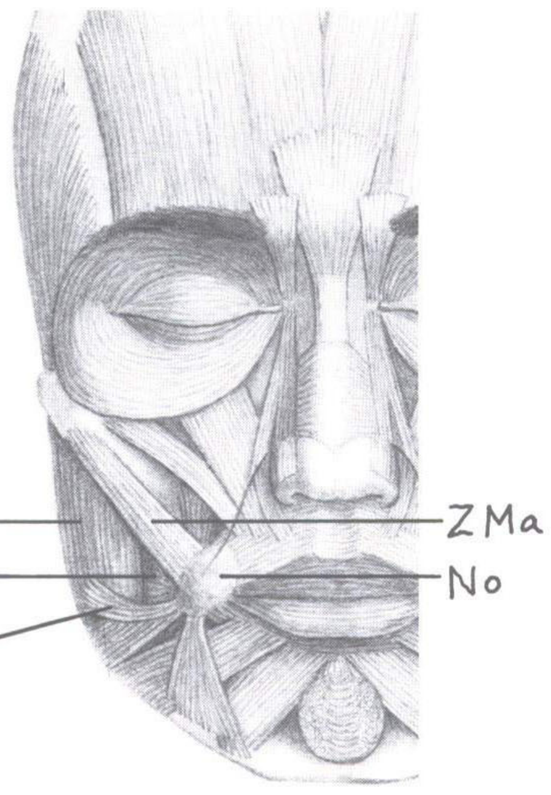
STRUCTURE This relatively deep, quadrilateral muscle forms the lateral wall of the cheek, lying on the outside of the teeth. The thick buccal (cheek) fat pad lies on the muscle's outer surface.

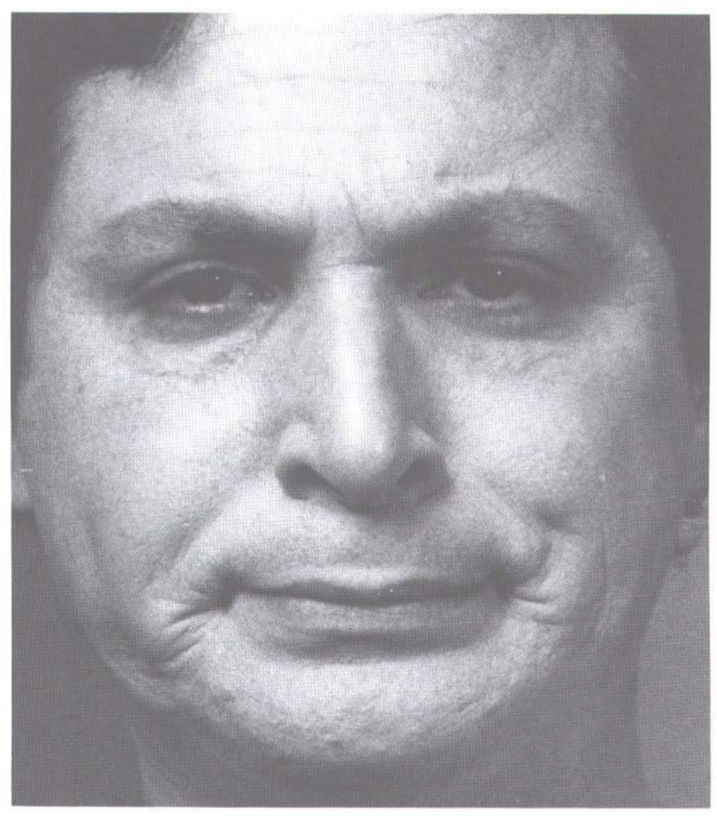
EFFECT The angle of the mouth is pulled inward or puckered inward and is usually also pulled slightly upward, curving the mouth line slightly upward at its ends. Lines may radiate from the angle of the mouth, especially one that passes outward and downward. The lips are widened and elongated as they are pulled around the cylinder of the muzzle, and the fleshy prominence of the chin is widened and flattened slightly. The lower end of the nasolabial furrow may deepen, while the cheek tissue just lateral to the dimpled angle of the mouth develops several bulged forms.

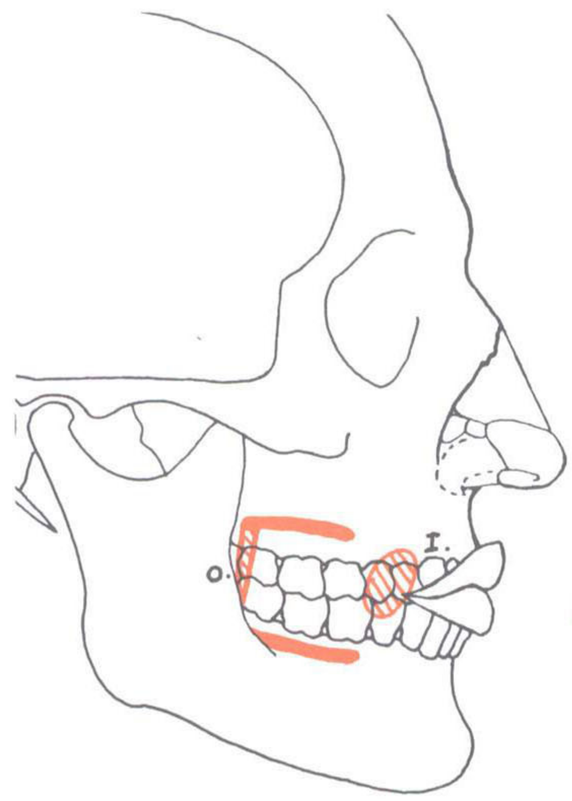
EXPRESSION Sarcastic smirk, annoyance, contempt, disapproval. These emotions are expressed by either unilateral or bilateral contraction of the buccinator.

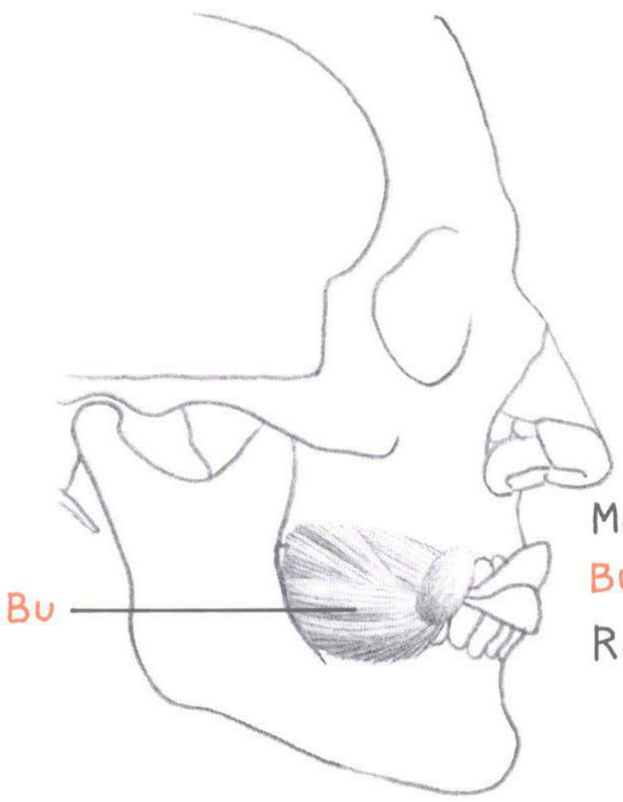


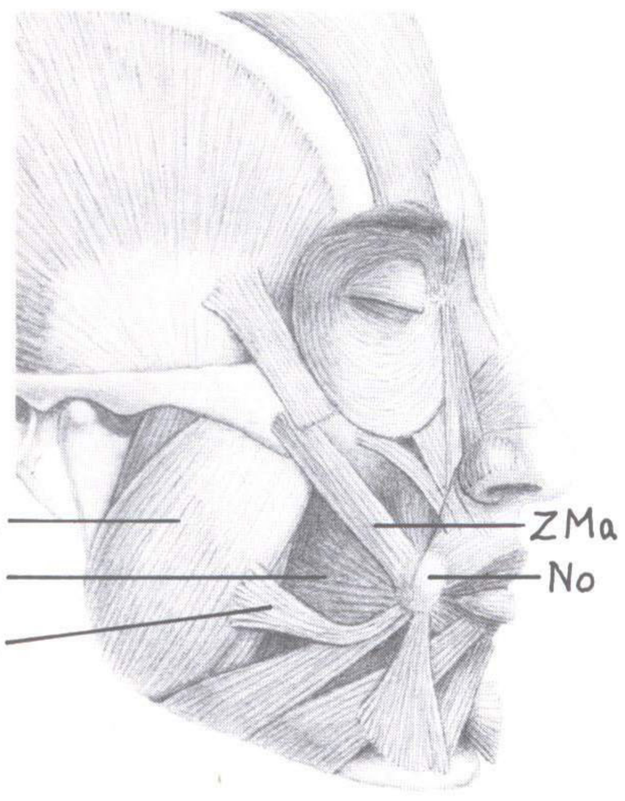


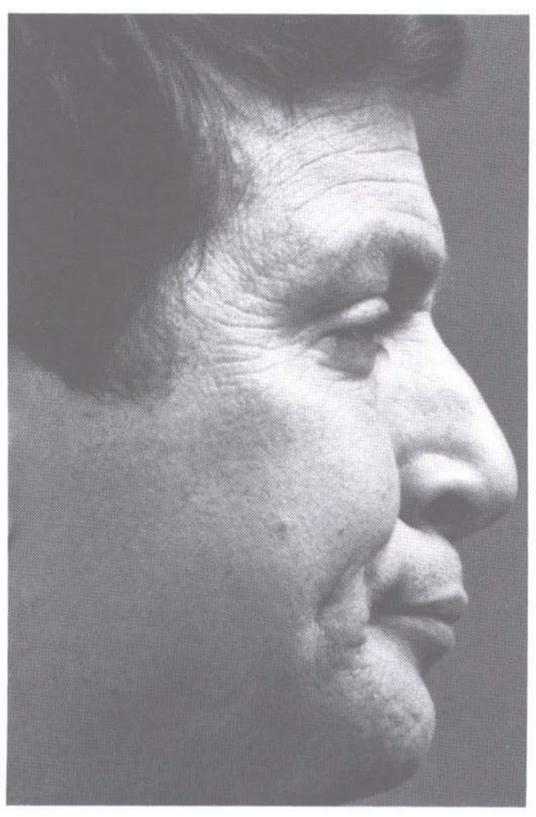












ZMa *Zygomaticus major*

Depressor Anguli Oris (Triangularis; Triangularis Menti)

ORIGIN *Deep head (long head):* A line on the outside of the body of the mandible, extending forward to the mental tubercle. This line is variable in length—often the long head arises only from the mental tubercle at the corner of the chin. *Superficial head (caput latum):* The fascia covering the platysma and depressor labii inferioris.

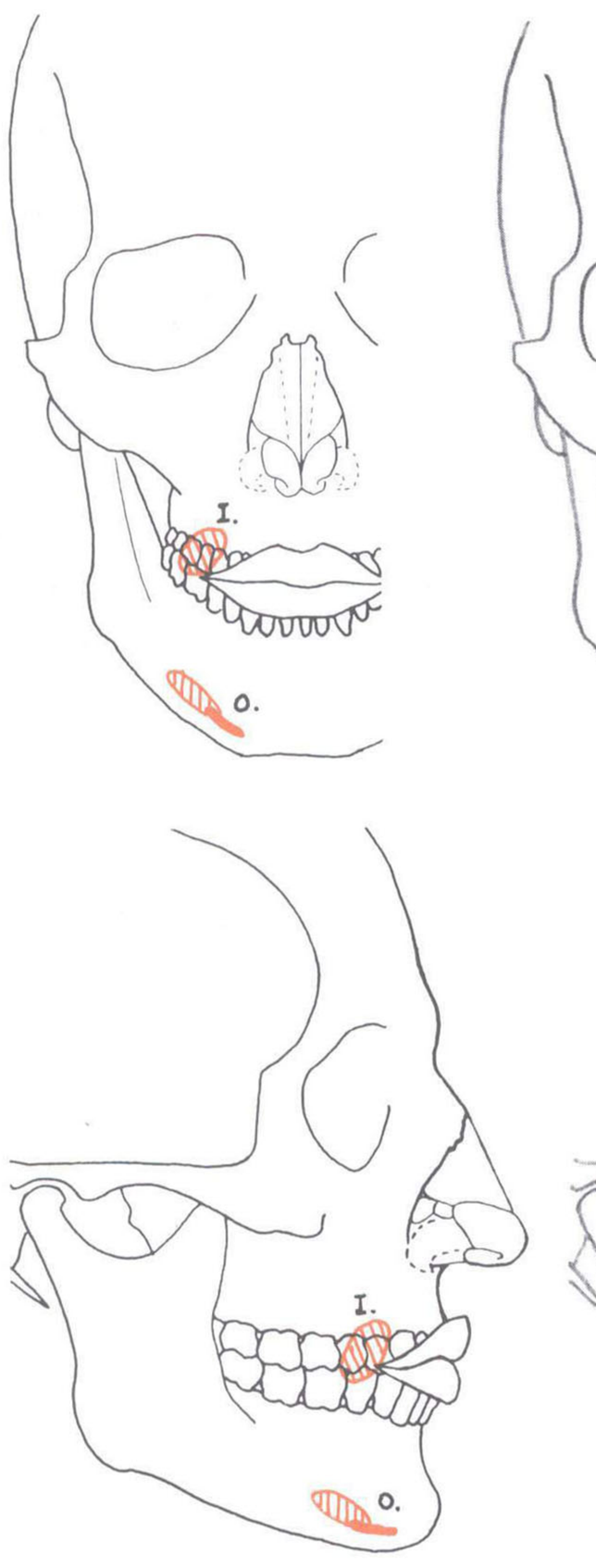
INSERTION The muscular node at the angle of the mouth.

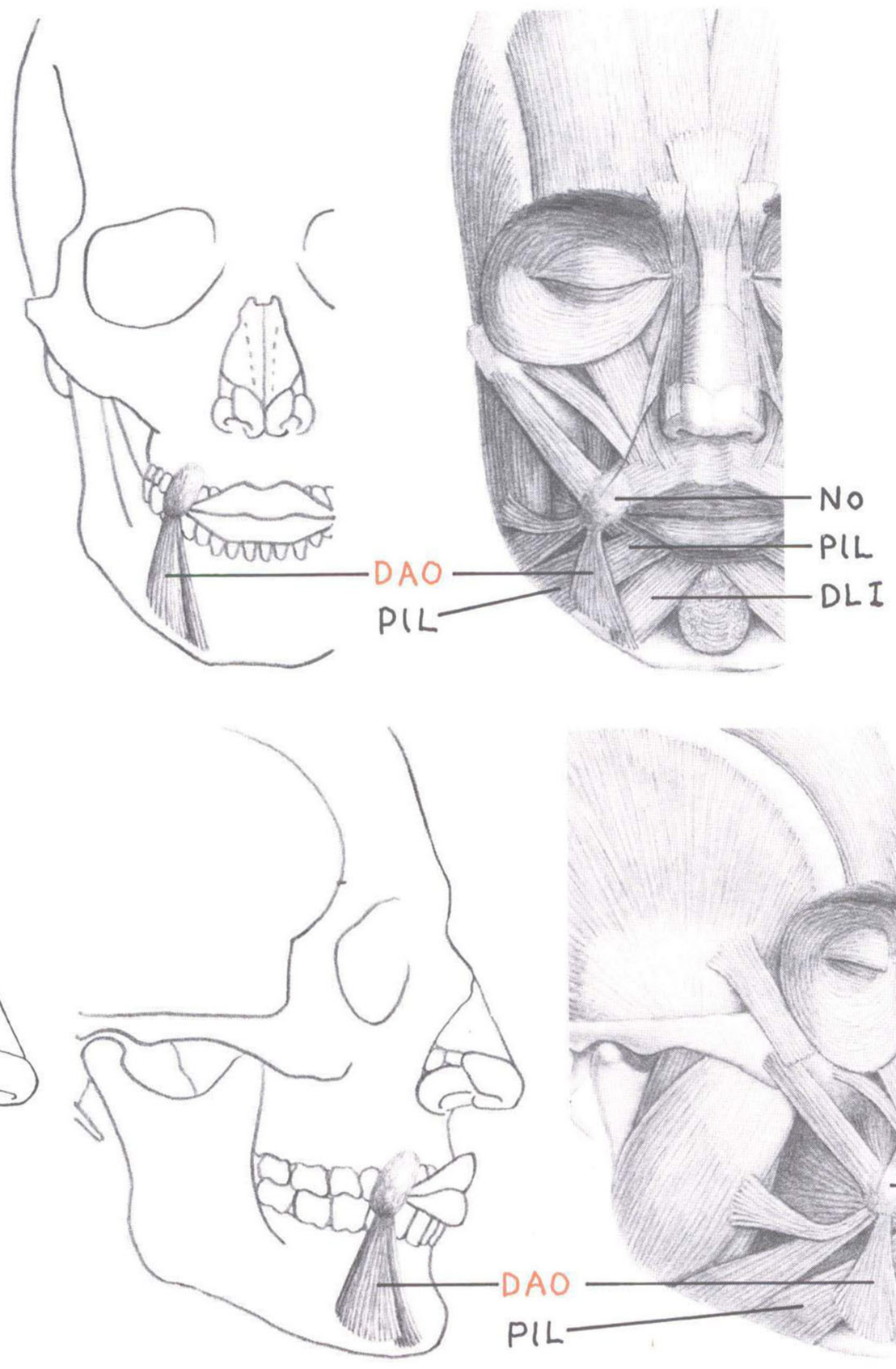
ACTION Pulls the node (and angle of the mouth) only slightly downward and laterally from its normal resting position. This muscle is the antagonist of the zygomaticus major, and the long head may be seen on the surface as a raised ridge during strong smiling action as the zygomaticus pulls the node upward and outward.

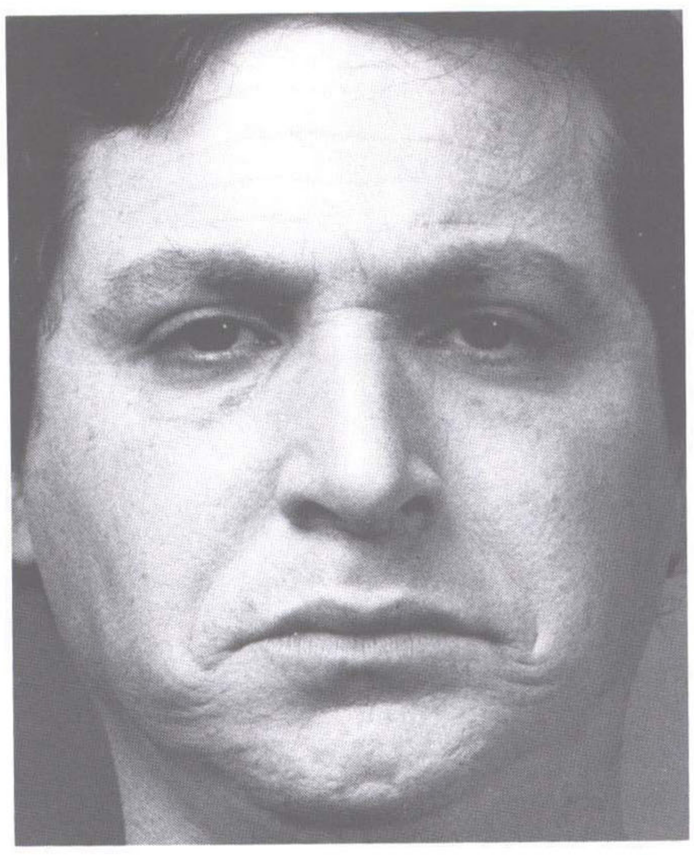
STRUCTURE The depressor anguli oris is made up of two layers: a superficial head arising from fascia, and a deep head arising from bone. The deep head is often narrow and strap-like, arising from the small bony area of the mental tubercle. Together, both heads create a fan-shaped muscle that converges into the node.

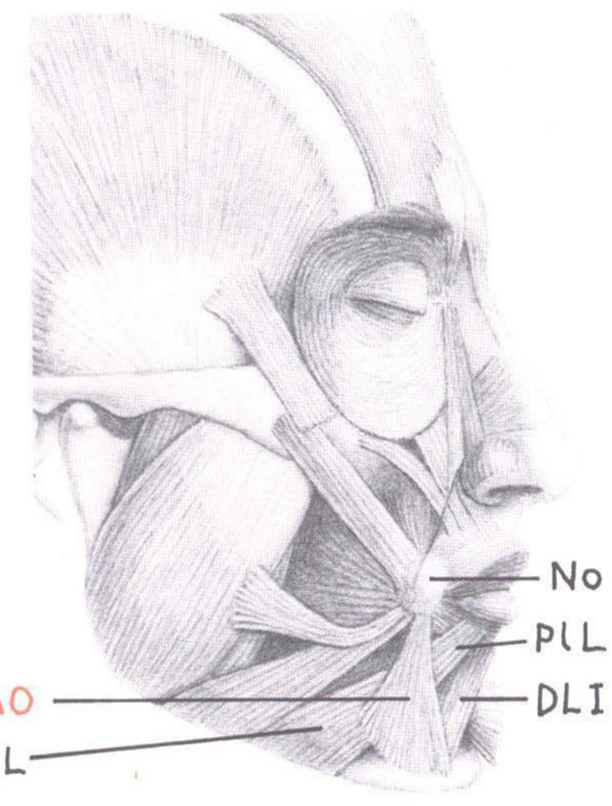
EFFECT The depressor anguli oris curves the mouth downward at its outer corners, which also lengthens the nasolabial furrow while deepening its lower end (producing the "long face" of sadness). It widens the mouth slightly and stretches the lips, flattening them. Strong contraction will produce several bulging forms below and lateral to the angle of the mouth. The furrow descending obliquely from the angle of the mouth is deepened and prolonged.

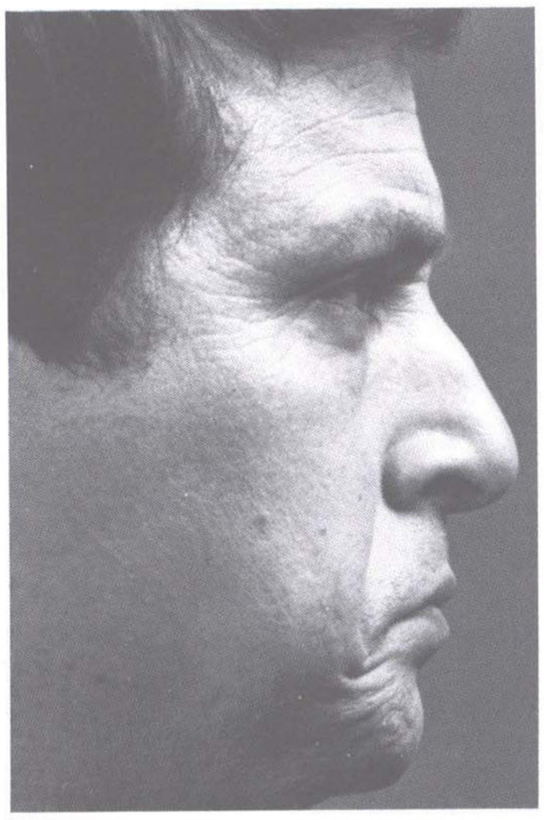
EXPRESSION Sadness, grief, sorrow, depression; disgust.











DAO *Depressor anguli oris* **DLI** *Depressor labii inferioris* **Me** *Mentalis* **No** *Node*

Depressor Labii Inferioris (Quadratus Labii Inferioris; Quadratus Menti)

ORIGIN An oblique line on the outside of the body of the mandible, just superior to the origin of the depressor anguli oris.

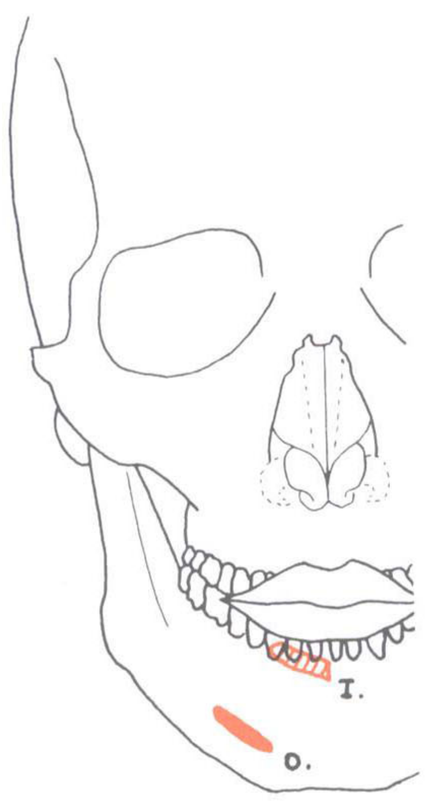
INSERTION The skin of the medial portion of each half of the lower lip, almost up to the red part, and into the substance of the orbicularis oris. The fibers of these muscles of each side of the face blend at the midline just below the lower lip.

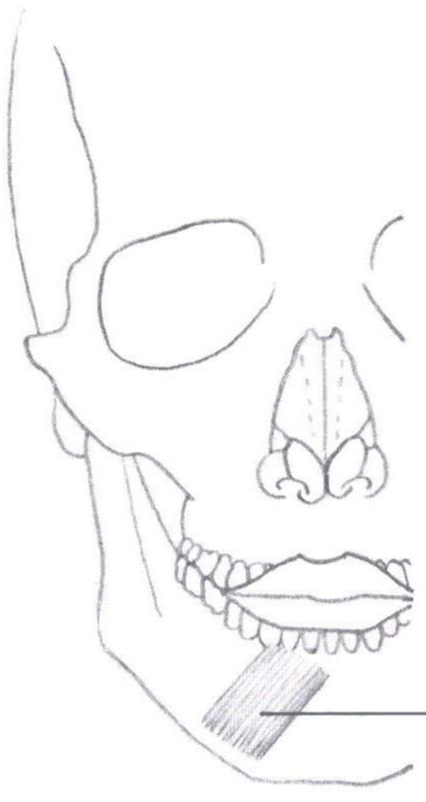
ACTION The muscles of both sides contract together to pull the middle third of the entire lower lip straight downward. This parts the lips, exposing the teeth and lower gum (also see action of labial platysma). The depressor labii inferioris assists in eversion of the lower lip, exposing the inside wet mucous membrane. Its medial fibers push the chin prominence downward.

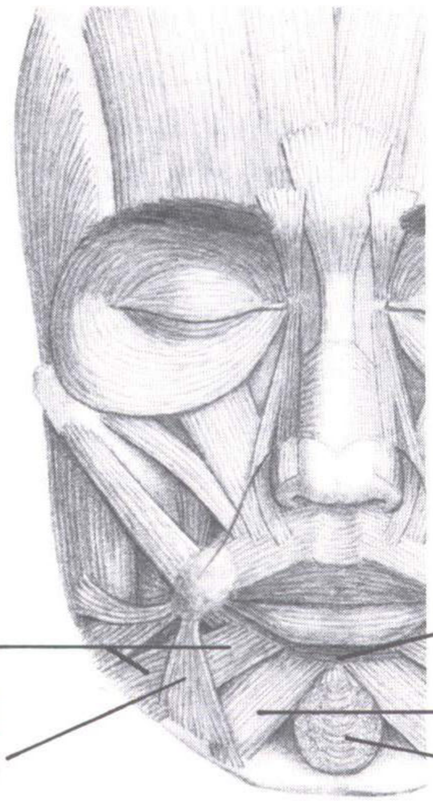
STRUCTURE The depressor labii inferioris is a quadrilateral muscle. Its lower lateral portion lies deep to fibers of the depressor anguli oris and the labial platysma.

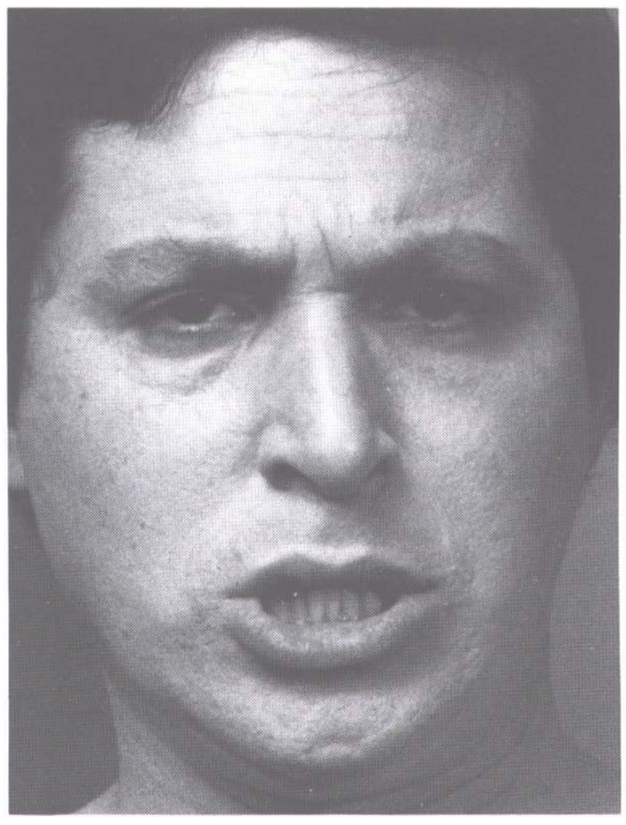
EFFECT The lower lip curves downward at its center. A horizontal skin fold (the mentolabial sulcus) below the lower lip may develop or deepen. The fleshy prominence of the chin is pushed downward. The mouth does not widen.

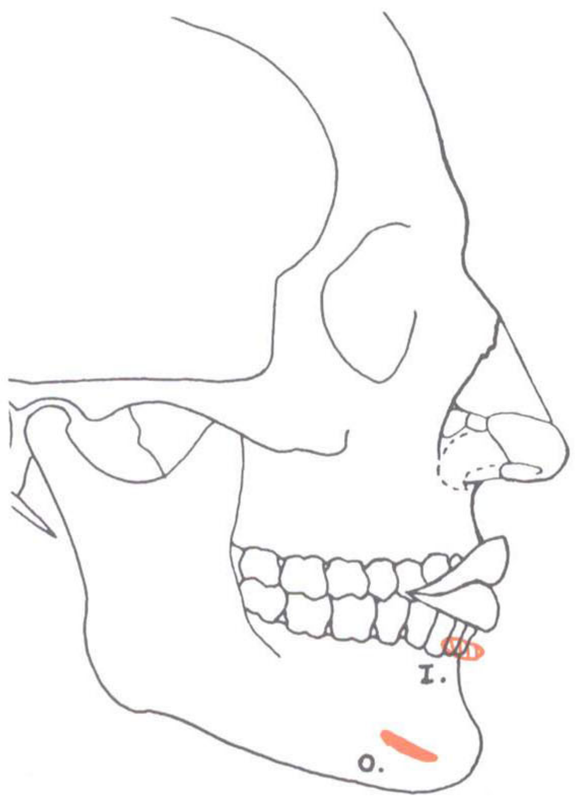
EXPRESSION Primarily used in speaking.

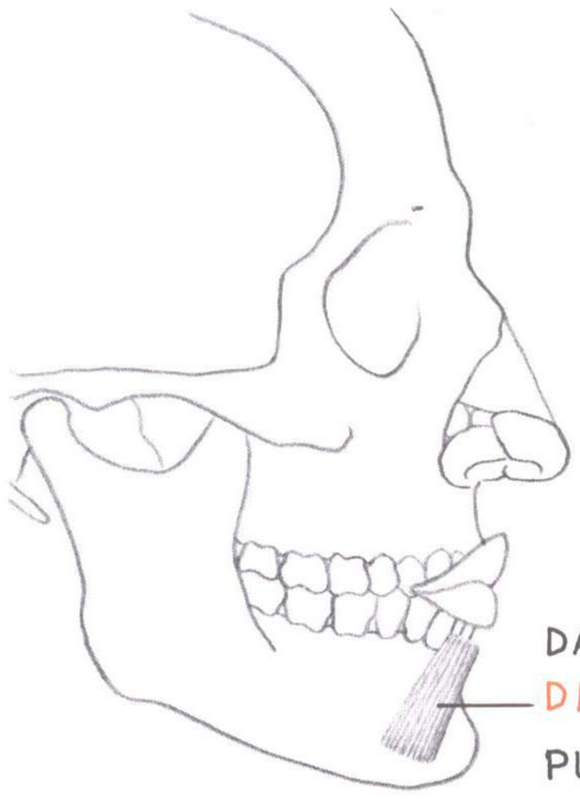


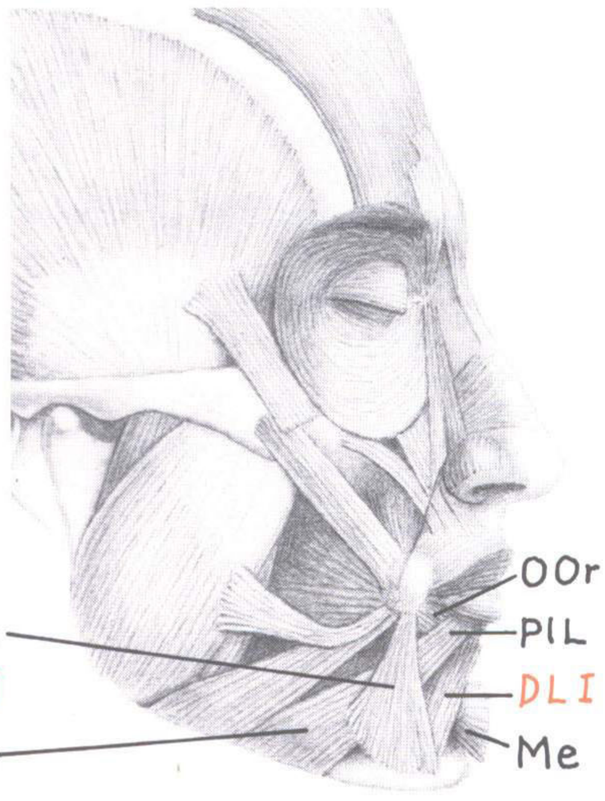


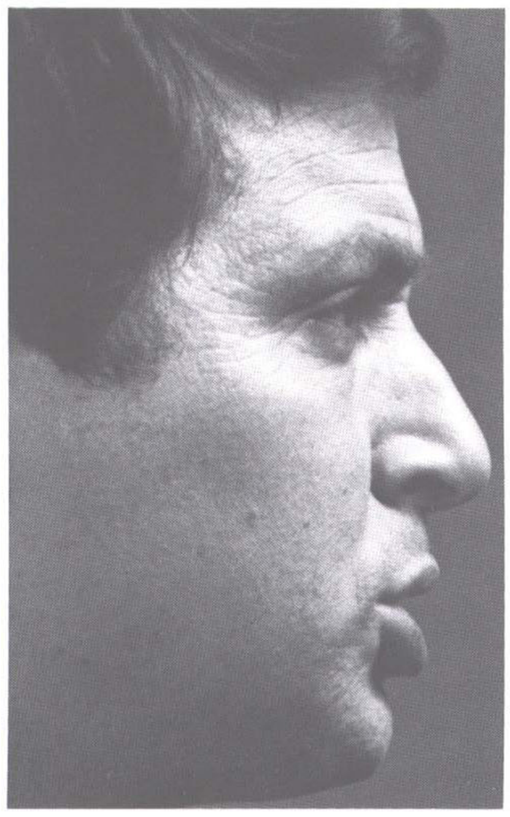




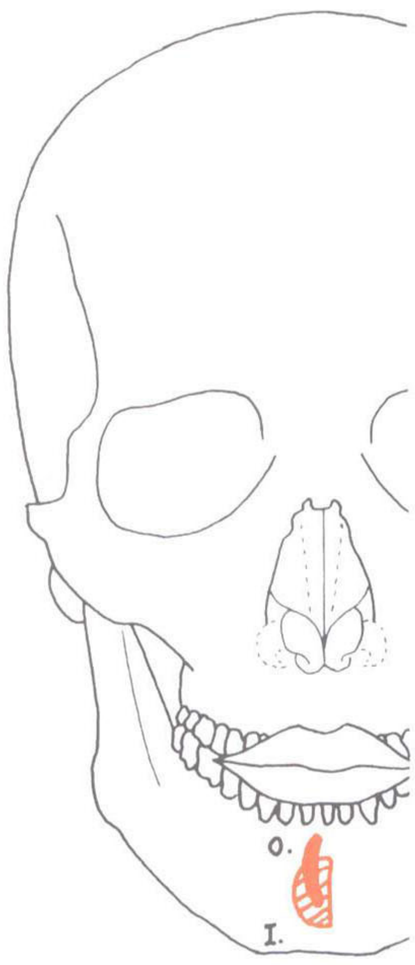




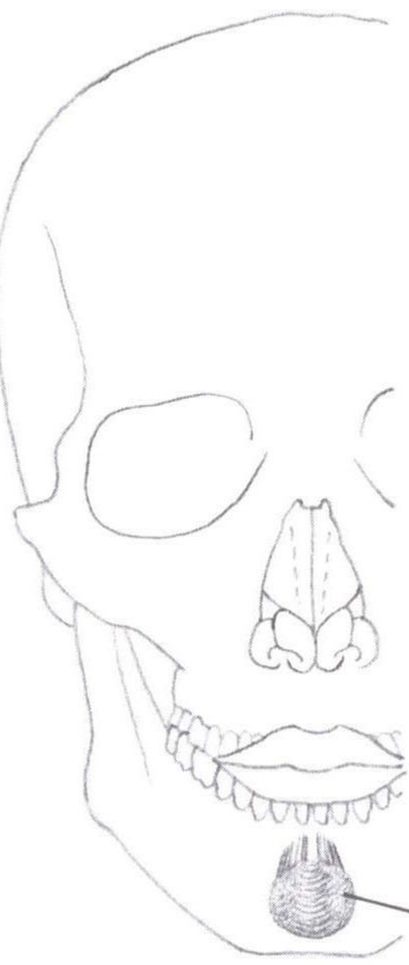




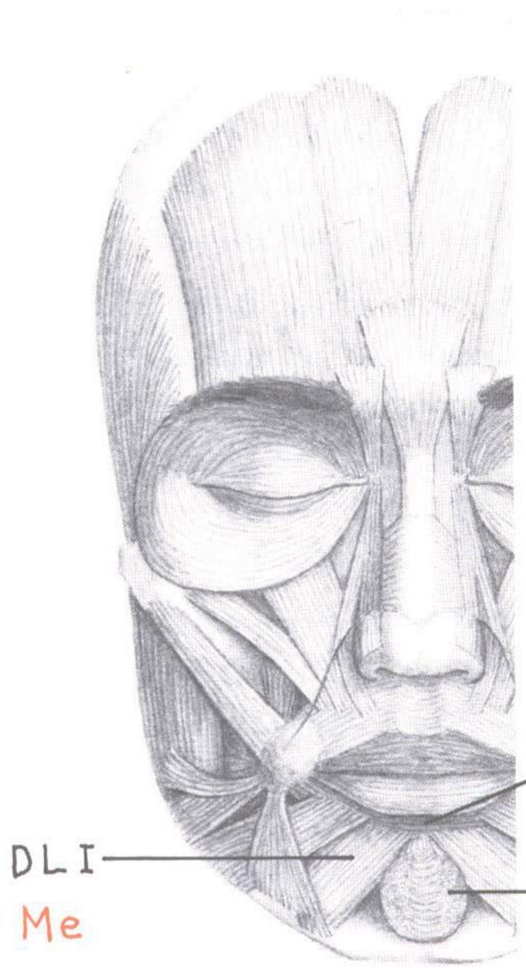
OOr *Orbicularis oris* **PlL** *Platysma—labial portion*

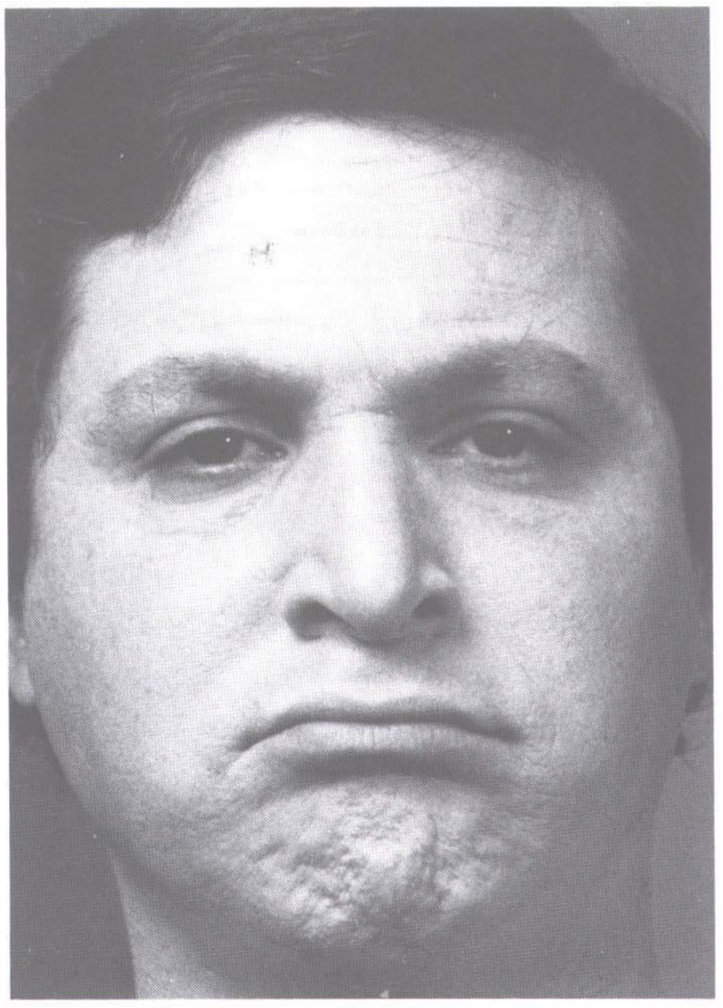


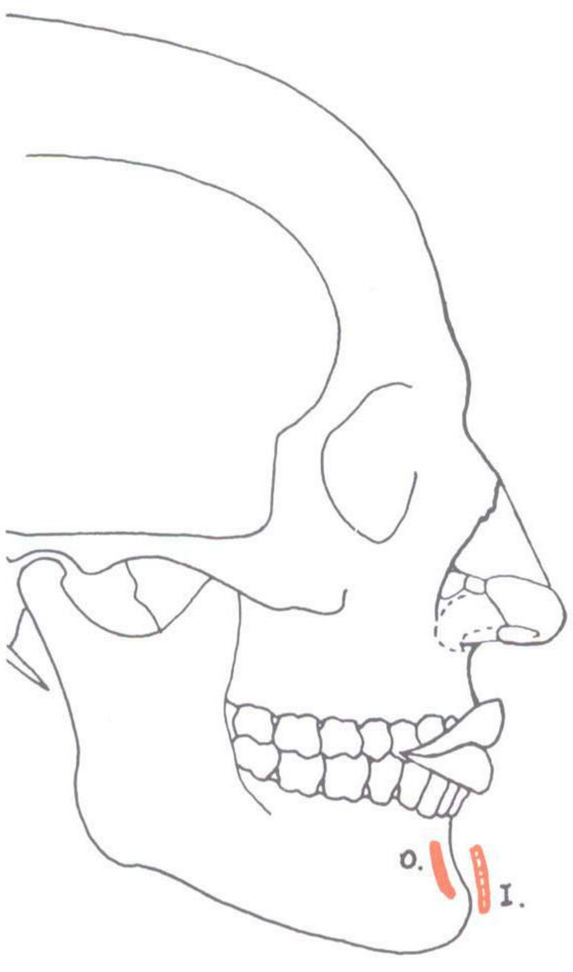
ATTACHMENTS ON ONE SIDE

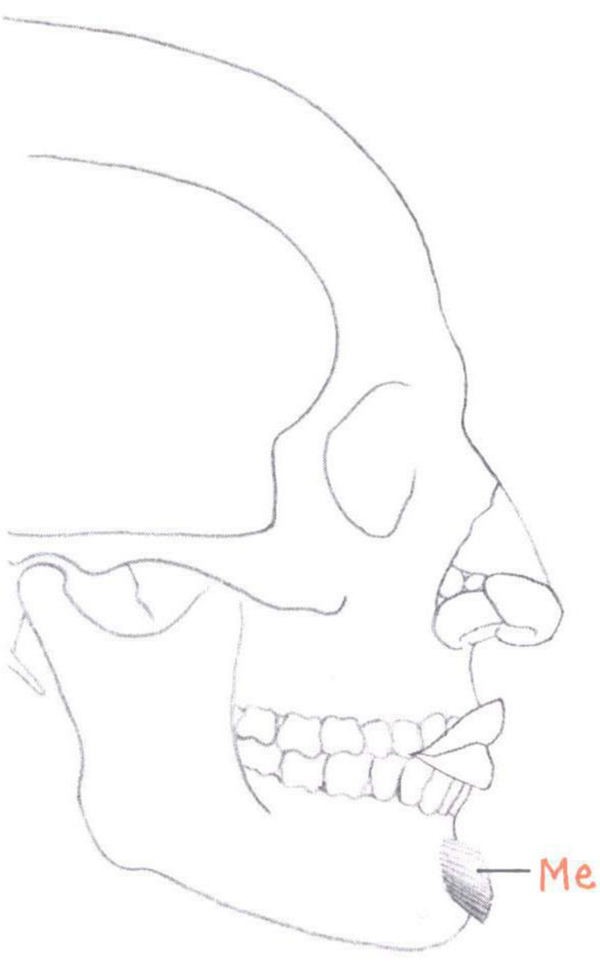


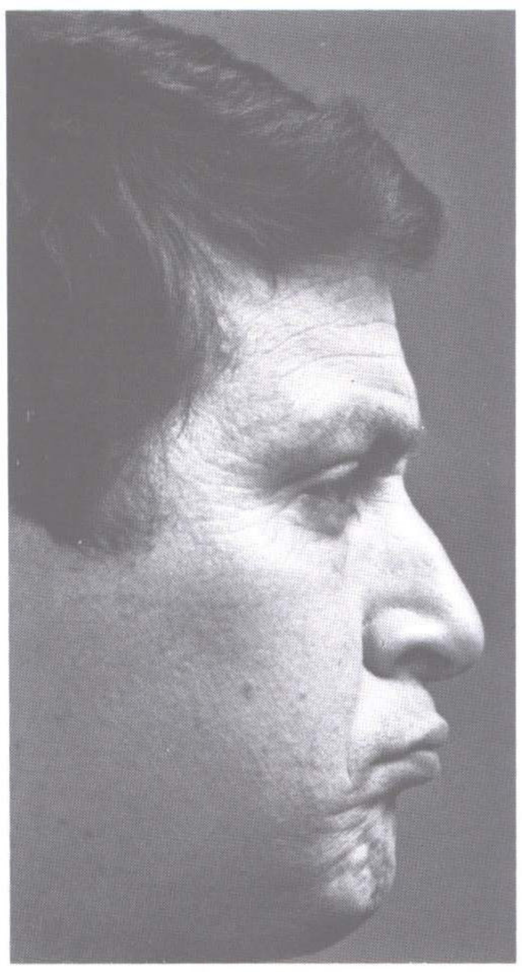
MUSCLES OF BOTH SIDES











DLI *Depressor labii inferioris* **Me** *Mentalis* **OOr** *Orbicularis oris*

Mentalis
(Levator Menti; Levator Labii Inferioris)

ORIGIN A vertical line on the front of the lower jaw, below the roots of the teeth and just to the side of the midline.

INSERTION The skin of the front of the chin (medial and lateral fibers) and into fibers of its fellow from the other side (medial fibers only).

ACTION Raises the fleshy prominence of the chin, which in turn pushes up the lower lip. This is a powerful action. If the mouth is closed, the lower lip will then push up the upper lip. It indirectly assists in protruding (everting) the lower as well as the upper lip by pushing up the lower lip. Protrusion of the lower lip produces a pout. The muscles of both sides of the face always work together.

STRUCTURE The mentalis muscles of both sides of the face form a conical mass that radiates outward from the small, narrow origins on the front of the mandible. From the side view, its belly has a fan-shaped outline—the uppermost fibers are horizontal, while its lowest fibers are almost vertical.

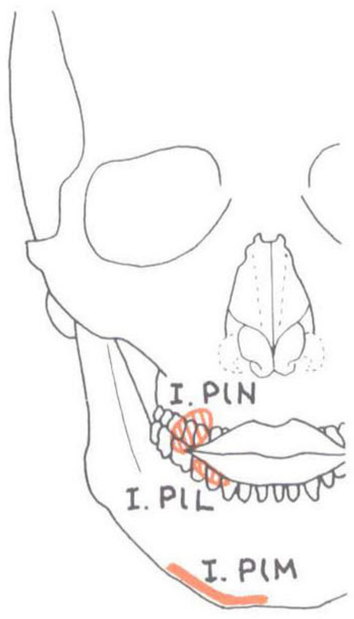
Lying just off the midline on the front of the chin, the muscle of each side is divided into medial and lateral portions. The lateral fibers insert directly into the skin. The medial fibers project forward—some join the medial fibers of the mentalis of the other side to form a muscular loop, while others insert into the skin. This loop embraces and attaches itself to a fibrous pad that rests on the bony prominence of the front of the mandible. The pad is separated from the bone by a lubricated bursa. When the mentalis contracts, the fibers that insert into the skin pull the skin of the chin upward. More importantly, the muscular loop pulls the fibrous pad upward, sliding it over the bony prominence of the chin. The pad in turn pushes upward against a muscular mass made up of the central fibers of the orbicularis oris of the lower lip and the midline fibers of the depressor labii inferioris, forcing this mass upward. This mass pushes the lower lip upward.

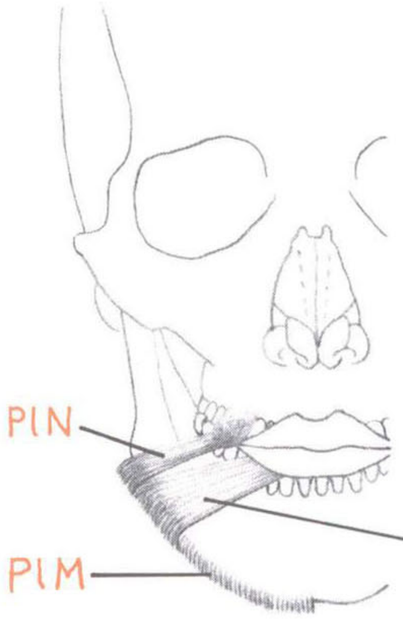
When some of the medial muscular fibers of the mentalis are not present, the skin adheres directly to the fibrous pad, creating a **chin dimple** or **cleft of the chin.**

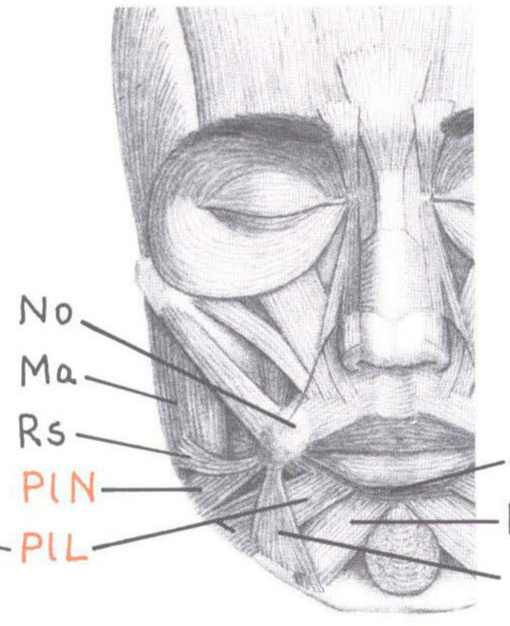
EFFECT Contraction of the mentalis makes the chin rounder and more pronounced in the front view, yet flatter in the side view. Wrinkles and numerous small dimples form on the entire fleshy prominence of the chin. A horizontal skin fold, the mentolabial sulcus, develops or deepens below the lower lip. The mouth line curves downward at its ends as the middle portion of the mouth is pushed upward. The red part of the lower lip appears narrower as it is pressed against the upper lip. The chin becomes hard when the mentalis contracts.

EXPRESSION Sadness, grief; anger, disdain; doubt, determination; disgust. The mentalis is used to conceal extreme sadness (crying) by forcing the mouth closed when one begins to cry.

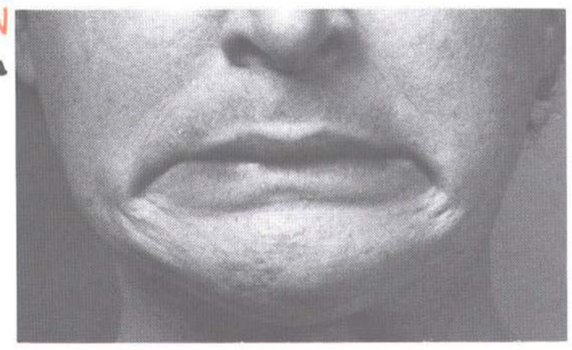
The mentalis and depressor anguli oris often contract together, for a moment only, as a conversational emphasizer (not an expression of emotion).



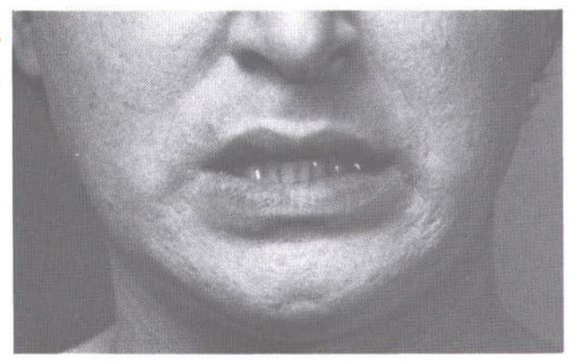


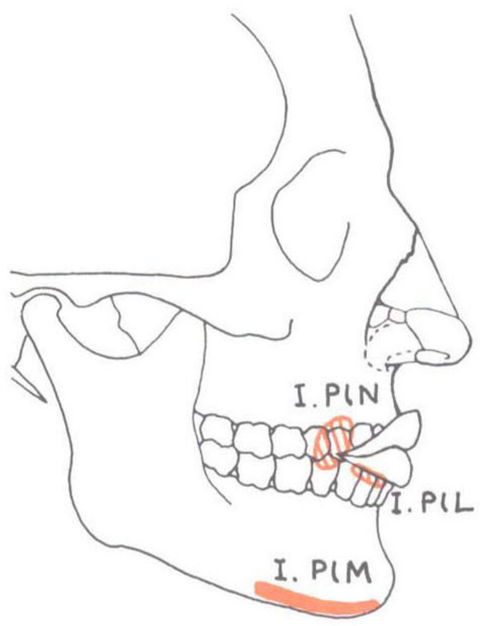


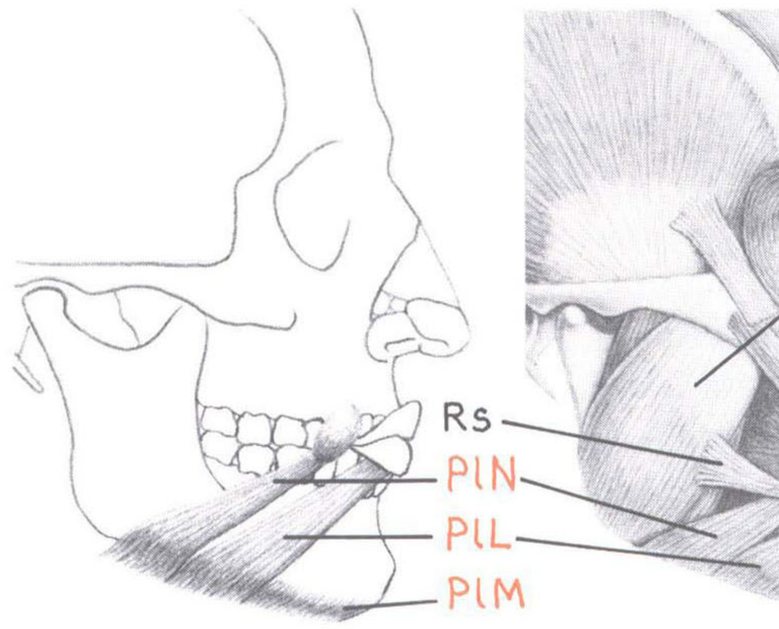
PlN



PlL







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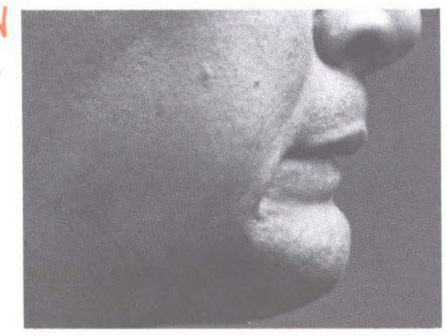

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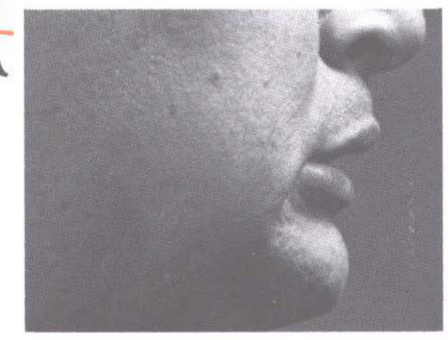
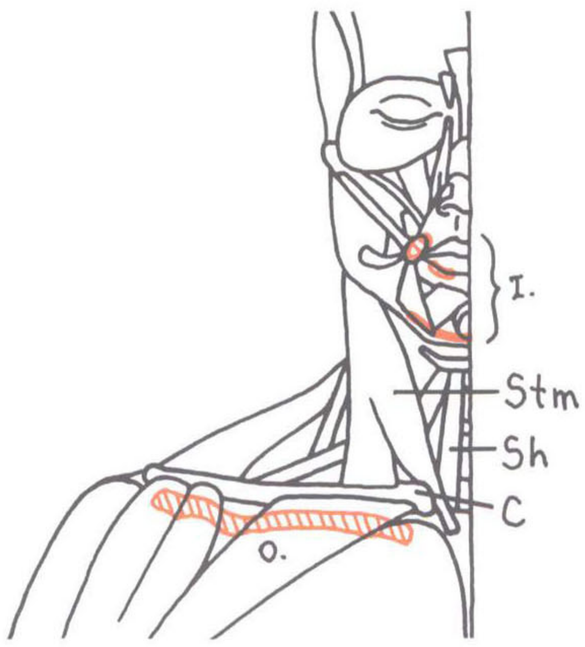
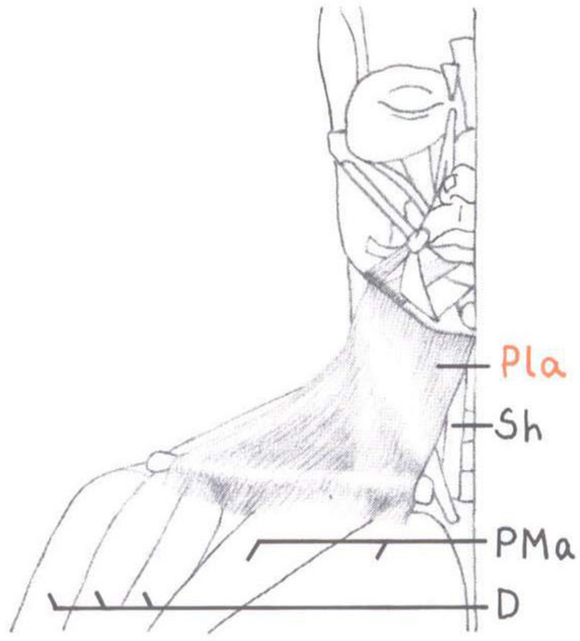
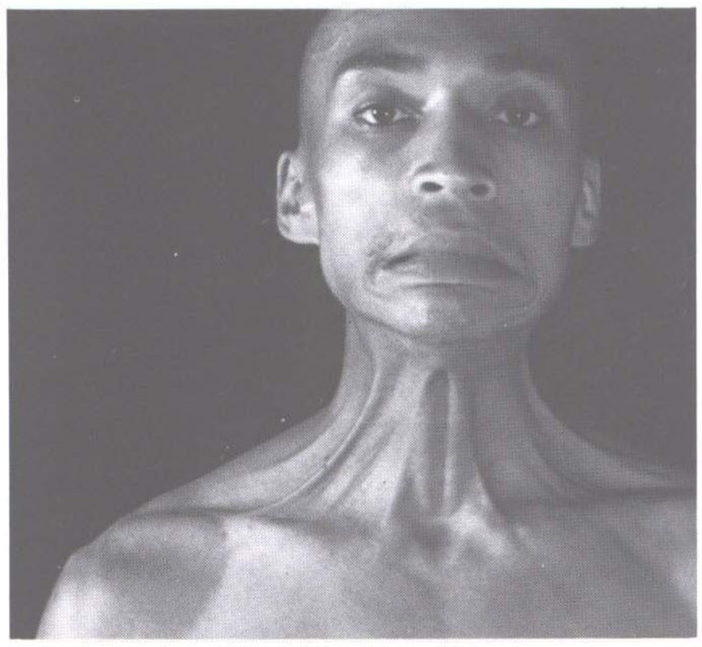
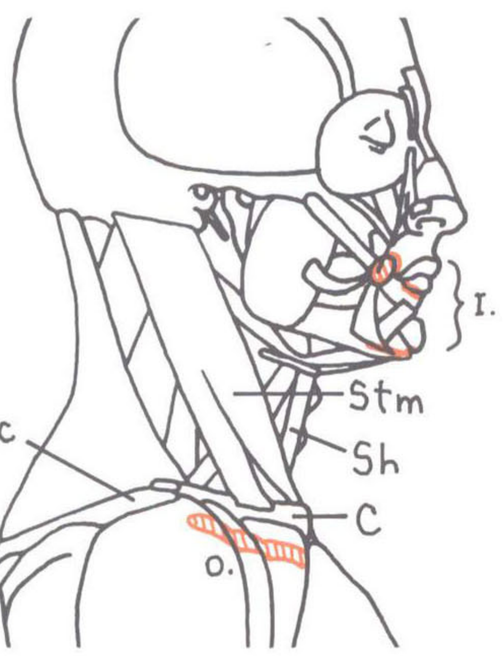


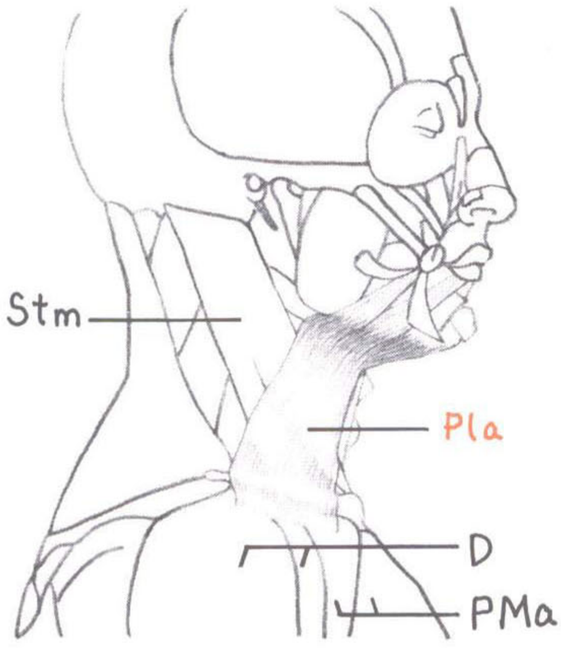


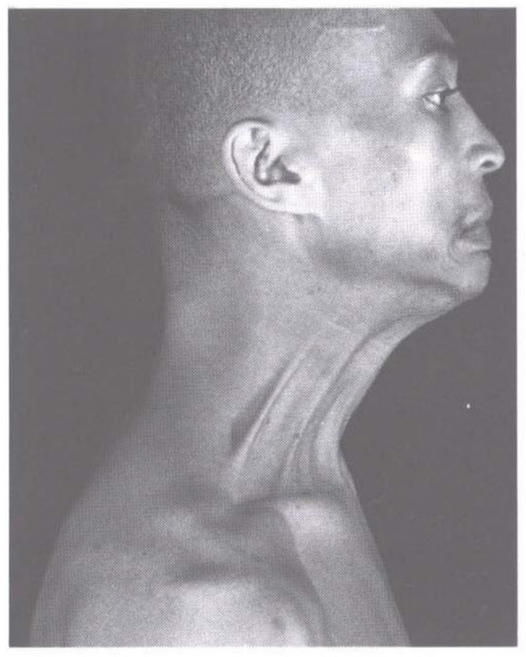




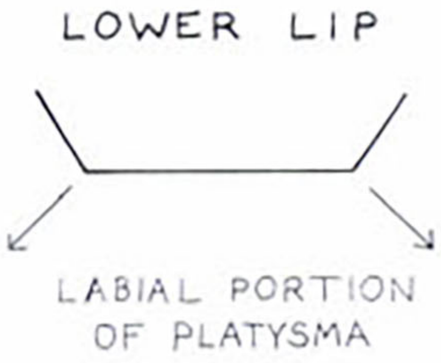
ENTIRE MUSCLE ↕







Ac *Acromion* **C** *Clavicle* **D** *Deltoid* **DAO** *Depressor anguli oris* **DLI** *Depressor labii inferioris*
Ma *Masseter* **No** *Node* **OOr** *Orbicularis oris* **Pla** *Platysma* **PlL** *Platysma—labial portion*
PlM *Platysma—mandibular portion* **PlN** *Platysma—nodular portion* **PMa** *Pectoralis major*
Rs *Risorius* **Sh** *Sternohyoid* **Stm** *Sternomastoid*



Platysma

STRUCTURE The platysma is a large, wide, thin muscular sheet. It is divided into three elongated portions—the **nodular, labial,** and **mandibular portions.** The posterior edge of the platysmal sheet runs from the angle of the jaw to the inner border of the acromion. The front edge, beginning at the chin, remains fused with the muscle of the other side halfway down to the hyoid bone, at which point the two sides separate and diverge, exposing the throat cartilages. The front edge then obliquely crosses *over* the inferior end of the sternal head of the sternomastoid (lateral to the sternohyoid muscle which passes *under* the sternomastoid). Finally, it passes over the medial end of the clavicle before ending on the chest. Both the anterior and posterior edges become visible when the muscle is tensed. As a person ages, the anterior edges become cordlike and hang loosely away from the front of the neck, even when the platysma is relaxed.

The labial platysma and the depressor labii inferioris form the **lower labial tractor.**

The structure of the platysma is extremely variable, but all three portions are commonly present. Very often, additional lateral fibers of the platysma continue upward onto the side of the cheek. These fibers do not seem to function as agents of facial expression.

ORIGIN *Entire muscle (includes all three portions):* The front of the chest just below the clavicle; specifically, from the superficial fascia covering the clavicular portion of the pectoralis major and anterior portion of the deltoid.

INSERTION *Nodular portion:* The muscular node at the angle of the mouth. *Labial portion:* The skin of the middle third of one side of the lower lip, up to the red lip margin. Deeper fibers penetrate the body of the orbicularis oris. *Mandibular portion:* The lower edge of the outer surface of the body of the mandible.

These insertions function as an origin when the lower jaw is stabilized and the entire platysma pulls up (or primitively "shakes") the skin of the neck and upper chest.

ACTION *Nodular portion:* Powerfully pulls the node (and angle of the mouth) mostly outward and slightly downward (the lips stay closed). *Labial portion:* Pulls the middle third of one side of the lower lip downward and outward, usually parting the lips. This portion also assists in eversion of the lower lip (see action of depressor labii inferioris). *Mandibular portion:* Pulls the lower jaw downward, opening the mouth.

The nodular and labial portions of one side of the face can work together or independently. These portions of both sides of the face can contract bilaterally or unilaterally. The entire platysma also lifts the skin of the chest, raising the breasts and nipples.

EFFECT The nodular portion stretches, flattens, and smooths the lips, especially the lower lip. It widens and flattens the lower face, and the furrow passing downward and outward from the angle of the mouth is deepened and elongated. The prominence of the chin is flattened and widened. Skin forms, or ridges and wrinkles perpendicular to the line of pull of the nodular portion, develop between the angle of the mouth and the angle of the jaw. The labial portion squares off the lower lip. Because the nodular and labial portions pass down the side of the neck, their fibers can be seen and felt contracting when they pull the angle of the mouth and the lower lip. There is no muscular activity on the neck when the depressor labii inferioris contracts. This distinguishes between contraction of the labial platysma vs. the depressor labii inferioris.

When the entire platysma is tensed, it becomes drawn into numerous long, thin, parallel, oblique, high raised ridges that pass downward, laterally, and posteriorly on the neck, from the lower edge of the jaw to the clavicle. This has the effect of widening the neck and deepening the suprasternal notch. These ridges are not seen on the face.

EXPRESSION Fear, horror, terror; pain, strain; disgust; anger; crying.

Expression of the Emotions

EMOTIONS are the subjective aspects of conscious feelings; they range from a mood, a feeling, an attitude, a state of mind to a character trait. Emotions can be related to three sets of bipolar scales: pleasant or positive (e.g., happiness) vs. unpleasant or negative (e.g., anger); attention (e.g., surprise) vs. rejection (e.g., disgust/contempt); and intensity—neutral vs. high intensity (highly expressive). Experiencing an emotion can be very brief (seconds) or can remain for a long period of time. A mood can last several days. An attitude or a state of mind can be a long-term condition. A character trait can be an almost permanent emotional state. Emotions are caused and modified by external (environmental) and internal (psychological) stimuli.

EXPRESSIONS are bodily manifestations of emotions. They serve to communicate or broadcast emotions. Producing expressions is a form of behavior, brought about by anatomical activity. Emotions are most effectively expressed on the face by the muscles of facial expression. Facial expressions are clear, precise, stereotyped signals (either strong or subtle) that have become exaggerated through evolution in order to communicate information between individuals.

Parts of the body other than the face may also be involved in producing expression. Hands, head position, posture, and eye movement can communicate emotion. Clenching the jaw and increased, decreased, intensified, or halted rate of breathing suggest emotional conditions. Noting changes in the vascular system, such as distension of the veins of the forehead, temple, and neck, pulsing of the temporal artery on the temple, and a flushed (red) or pale (loss of blood) face, are also keys to analyzing emotion.

There are **six basic emotions: happiness, sadness, surprise, fear, anger,** and **disgust/contempt. Interest/excitement** is considered by some to be a seventh basic emotion.

The way the basic emotions are expressed on the face is *inherited and not learned*. Each emotion has specific facial expressions, or **facial displays**, which are innate, universal, and constant across all cultures. Some basic emotions, however, have additional cultural-specific facial patterns which are learned. Physical gestures (e.g., hand movements) are also culture specific.

Blends are combinations of more than one basic emotion that appear simultaneously on the face, such as fear and surprise, or anger and contempt. Each basic expression can have different versions (e.g., open or closed mouth), and each version can be altered to vary intensity or to otherwise modify the basic expression (e.g., apprehensive, scared, terrorized—all different intensities of fear expressions). A **neutral** face has no muscle contraction (other than normal muscle tone) and shows no expression.

The expression of the emotions on the face is produced by the contraction of the facial muscles. They can contract singly, or in specific combinations, to reveal—or broadcast—the emotions one is feeling. Their contraction changes the location and shape of the facial features (eyelids, eyebrows, nostrils, mouth/lips, cheeks, chin, etc.) with a resultant production, deepening, or moving of skin wrinkles. These changes are effected by the contraction, shortening, and subsequent pulling action of the facial muscles. We are all extremely adept at receiving and interpreting these emotion signals from the face, even those expressions that are barely perceptible and last only for the briefest moment; the slightest smile, sneer, or frown is immediately registered by the observer.

Because of all the possible combinations of different muscle contractions, as well as their variations in intensity, the face is capable of producing thousands of different expressions. Faces can be active, animated broadcasters of emotion or passive, subtle communicators.

Some people may have fixed or permanent patterns in their face that *resemble* facial expressions (forehead wrinkles, lowered brow, angle of mouth pulled down) but are *not* actual facial expressions. When these people produce facial expression, they must increase these permanent conditions (deepen the wrinkles, further lower their brows or the angles of the mouth) in order to produce expression.

Expressions may be **symmetrical** (equal intensity on both sides of the face), **asymmetrical** (appearing on both sides of the face, but stronger on one side), or **unilateral** (appearing on one side of the face only). Sometimes an expression may be asymmetrical by showing one emotion on one side of the face and another completely different emotion on the other side (one corner of the mouth pulled upward—happiness; the other side pulled down—sadness). Determining the true felt emotion is obviously very difficult in these cases. Other facial regions must then be analyzed to ascertain the true emotion. Also, some people have the appearance of different expressions on the two sides of the face when the face is *at rest*. In this situation, emotions are not being expressed, but rather this is the static resting position of that individual. Because of these variables, and because of individual facial and emotional idiosyncrasies, one must ideally compare an individual's neutral face to their expressive face to determine which actions and movements have actually taken place.

True expressions are *involuntary* and broad-

cast a basic emotion that the person is actually feeling. When a second true felt emotion is experienced simultaneously with the first, its expression is involuntarily added to the face, producing a **true blend** (surprise with happiness). True emotions are usually displayed on the face only briefly, usually up to five or ten seconds. They may, however, last longer, such as in extended smiling and crying.

False expressions do not convey what a person is actually feeling. They are produced *voluntarily* in one of three ways:

1. One can **simulate** an emotion when none is being felt (false smile on a neutral face).
2. One can **mask** or **hide** (partially—producing a blend, or completely) a true felt emotion with a different expression that is not being felt (false smile added to a true angry face).
3. One can **neutralize** the face—eliminating facial expression—so as to show no emotion when one is actually being felt, or **deintensify** a true expression (repressed smile).

False expressions are used to control or enhance messages in an honest way or for deceit. False expressions can be detected as such when the true expression leaks out, or when the simulation, mask, or neutralization is done poorly. While the expressions of the six basic emotions are universal, the way they are interfered with to create false expressions varies among cultures, families, and individuals. These modifications must therefore be learned. False expressions are often asymmetrical or unilateral.

Expressions can be varied in intensity, both voluntarily and involuntarily, by (1) increasing or decreasing contraction of the active facial muscles (little smile to big smile; anger to rage), (2) increasing the time the expression is seen on the face, or (3) adding or eliminating facial areas (forehead, eyelids, lips, etc.) that are normally involved in producing that expression (angry brows without angry mouth).

Certain facial movements are used *briefly* during speaking to emphasize a point. They may resemble specific expressions and may sometimes be used to convey the *idea* of that specific emotion visually rather than orally, but they are not expressing true felt emotions (e.g., winking, raising the eyebrows, drawing the eyebrows down and together, wrinkling the nose, or raising the upper lip). They are usually executed rapidly while speaking.

The face can communicate certain **physical sensations,** both pleasant and unpleasant. These are not emotions, and include tiredness, fatigue, agitation, exertion, pleasure, pain, and intoxication. Pleasure usually produces happiness, but not always. It is the opposite of pain, although pain can at times be pleasurable. The physical sensation of pain may produce the emotion of sadness, anger, or surprise.

When a person is preoccupied or lost in thought, especially when being spoken to, and disconnects from the conversation or surrounding activity, then he or she will develop a glazed stare. This is recognized by unfocused eyes and the divergence of the eyeballs (relaxation of the eye muscles causes lateral deviation of the eyeballs).

Other emotional or psychological states are pity, distrust, anxiety, calm, pride, irony, insecurity, shyness, modesty, helplessness, patience, affirmation, admiration, wonder, desire, negation, stupidity, hate, disdain, affection, soberness, love, tender feelings, reflection, resignation, devotion, meditation, boredom, determination, and jealousy. Some of these can be placed as variations within one of the basic emotions, while others may be blends. Some can be read on the face, while others can be surmised only be examining the situation. The circumstance is often a better key to determining what a person is feeling, as the face can at times be unreliable or impossible to decipher.

Shame/humiliation (embarrassment, guilt) is often communicated by the lowering of the eyes and head, as well as by blushing. It is sometimes considered a basic emotion.

The Basic Emotions

Numerous facial expressions exist for each basic emotion. Described here are some of the "classic" displays for each of the six basic emotions, as well as displays for the expressions of interest/excitement and pain/distress.

Happiness

Variations of the basic emotion (type/intensity): Contentment, joy, enjoyment, amusement, high spirits, laughter, ecstasy. The degree of intensity is determined by how far the angles of the mouth are pulled apart, how far the mouth is opened and the teeth exposed, and how much the eyes are squinting. Happiness ranges from a slight smile to a broad open-mouthed grin.

Appearance and muscle action:

- The angle of the mouth is pulled outward, upward, and backward; the lower end of the nasolabial furrow is pulled in same direction; the nasolabial furrow is deepened; the front of the cheeks are raised and puffed, which produces wrinkles under the lower eyelid and may also push the lower eyelid upward (narrowing the eyes). The distance between the bottom of the nose and the upper lip decreases. Thick vertical ridges form on the side of the cheek lateral to the angle of the mouth as the skin and cheek

fat become gathered into folds (zygomaticus major and malaris).

- "Crow's-feet" wrinkles radiate from the outer corners of the eyes (orbicularis oculi—orbital portion).
- Closed mouth: The lips remain together as they are stretched and flattened.
- Open mouth: The lower jaw is usually dropped. The upper teeth, lower teeth, and upper gum become exposed as the lips are retracted (upper and lower labial tractors). The lower labial tractor has a slightly stronger contraction than the upper; the upper lip remains straighter (more horizontal in the front view). The individual muscles of the upper labial tractors must all contract slightly and simultaneously. If one muscle predominates, a false (uncomfortable) smile will register on the face, or a second expression will be added (e.g., disgust). The same holds true for the lower labial tractors. During laughter, the labial tractors are in strong contraction, and the jaw is opened wide. To clearly see the labial tractors at work pulling the lips apart, observe a wide closed-mouth smile break into a strong, toothy grin.

Happiness characteristically produces a smile and is the most easily recognized emotion. It is a positive emotion, where one feels good. No activity takes place in the brows or forehead. The lower intensities of happiness are silent. Toward its extreme intensity, happiness becomes vocal; it is heard in the chuckle, giggle, and laugh. The most extreme form can include tears with the laughter. The smile is the most common emotional mask used to conceal other emotions; it masks anger, disgust, fear, etc. It often blends with the other basic emotions, especially surprise. Happiness is different from pleasure, which is a positive physical sensation, not an emotion. Happiness often appears when a person becomes relieved after experiencing a negative emotion.

In a repressed smile, the depressor anguli oris is contracted to counteract the pull of the zygomaticus major; however, the malaris still pulls the cheeks upward. The orbicularis oris also tries to suppress the smile by pulling the muscular node at the angle of the mouth medially; it may be counteracted by the risorius attempting to pull the node laterally. The risorius may therefore be active in a true smile, but its action is concealed by the more powerful zygomaticus major.

False and suppressed smiles can be indicated by uneven contraction of the labial tractors. A smile is often asymmetrical when it is false, or when anxiety interferes with it when it is used as a mask. In a true smile, the orbicularis oculi is involved, producing some lowering of the eyebrows, raising of the cheeks, and crow's-feet. In a false smile, the orbicularis oculi is usually not contracted (only zygomaticus major is), and no orbital or eyebrow movement takes place.

In a strong smile, a long raised ridge, formed by the continuous narrow bellies of the zygomaticus major and the deep head (long head) of the depressor anguli oris, develops between the side of the zygomatic bone and the mental tubercle of the chin.

During the expression of happiness, the lower face is widened and lifted.

Sadness

Variations of the basic emotion (type/intensity): Disappointment, loss, sulkiness, low spirits, hopelessness, sorrow, grief, dejection, depression, despair. Extreme sadness becomes vocal when weeping and crying are added.

Appearance and muscle action:

- The inner ends of eyebrows are raised and drawn together, which usually inclines the eyebrow; horizontal skin wrinkles develop on the *center* of the forehead only; the medial end of the eye cover fold is pulled upward, exposing the medial half of the upper eyelid (frontalis—medial portion only).
- The lateral part of the eye cover fold is pulled downward, covering the lateral half of the upper eyelid (the cover fold becomes oblique); the lower eyelid may be raised slightly as in a squint; the cheek may be pulled upward slightly (orbicularis oculi—orbital and palpebral portions).
- The upper eyelids may droop (relaxation of levator palpebrae superioris).
- Closed mouth: The angles of the mouth are pulled downward, causing the mouth to curve downward at the corners (depressor anguli oris). This action also pulls the lower end of the nasolabial furrow downward, lengthening it ("long face" of sadness).
- The chin may be raised, pushing the lower lip upward and then sometimes protruding (pouting) it (mentalis). Pushing the lower lip upward also increases the upward curvature of the mouth.
- The middle portion of the nasolabial furrow is pulled laterally (and deepened), in preparation for crying (zygomaticus minor).
- Open mouth: As sadness progresses to crying, the mouth opens and becomes squared-off (zygomaticus minor and labial platysma). The pull of these muscles may begin to show before the lips actually part, especially in the upper lip. In the open-mouth position, the angles of the mouth still remain pulled downward. The mentalis may push the center of the lower lip upward.

- The head and/or the eyeballs may be directed downward (faces or looks downward).
- Loss of all muscle tone in the face can also express sadness.

The eyebrows may appear to remain in their normal horizontal position after the medial portions of the frontalis have contracted. In this case, horizontal wrinkles across the center of the forehead, the exposure of the medial ends of the upper eyelids, and the lowering of the lateral ends of the eye cover folds are diagnostic of sadness. The eyebrow also usually develops an S curve or "kinking" in sadness because of the simultaneous contraction of the corrugator supercilii with the medial portion of the frontalis.

The eyes close or almost close during crying. In trying to suppress crying, the mouth is pushed closed by the mentalis, and it may tremble.

Sadness is a negative emotion—the opposite of happiness. It usually lasts a long time. It most often blends with anger and fear.

Suffering, anguish, and distress are blends of sadness (an emotion) with pain (a physical sensation).

Medial frontalis contraction *without* depressor anguli oris contraction (pulling the corners of the mouth down) can express submissiveness or pleading.

Surprise

Variations of the basic emotion (type/intensity): Slight surprise, questioning surprise, dazed surprise, dumbfounded surprise, awe, astonishment, amazement, startle.

Appearance and muscle action:

- The brows are raised straight up and arched; horizontal wrinkles appear across the *entire* forehead; the skin below the eyebrows is stretched (frontalis—both medial and lateral portions).
- The upper eyelids are raised in more intense versions of surprise, showing white above the iris (levator palpebrae superioris).
- The lower jaw drops with the mouth opening slightly or wide; the mouth opening is oval and horizontal or oval and vertical, depending on how far the jaw opens. The teeth are parted, and the lips and mouth are *always* relaxed.

The appearance of surprise on the face is very brief. It usually leads immediately to the next emotion (fear, happiness, disgust, etc.) and then blends with it. Surprise can be either a pleasant or unpleasant experience. The startle reaction functions as an interrupter which gets the recipient's attention; a second emotion usually soon follows. The startle is often begun with a rapid eye blink with the head pulled straight back.

The appearance of surprise on the face is similar to the appearance of fear.

Fear

Variations of the basic emotion (type/intensity): Apprehension, worry, startled fear, shock, terror, horror.

Appearance and muscle action:

- The brows are raised and drawn together; the brows become straight, not arched; horizontal wrinkles appear across the entire forehead; vertical wrinkles form between the eyebrows (frontalis—both medial and lateral portions, and corrugator supercilii). Often, only the medial portions of the frontalis contract with the corrugator, resembling the expression of sadness. The eyebrows will then be kinked.
- The upper eyelids are raised (levator palpebrae superioris).
- The lower eyelids are tensed upward (orbicularis oculi—palpebral portion).
- The mouth is usually opened (jaw drop).
- The angles of the mouth are pulled horizontally outward and slightly downward, stretching the lips (nodular platysma). The entire platysma may contract, producing high, ridged folds on the front and sides of the neck.
- The lips may be strongly parted, forming a rectangular opening in preparation for screaming. The nasolabial furrow also deepens (upper and lower labial tractors). Strong contraction of the nodular platysma will also be present.

Fear is an unpleasant emotion. Its expression can be maintained for a considerable period of time. Because it may be overwhelming, the features may appear to be locked or frozen in the contracted position. Fear is often preceded by surprise, and often blends with it. Restriction of blood to the face will lighten the face ("white with fear").

The muscular activity for fear basically widens the lower face and pulls it slightly downward.

Anger

Variations of the basic emotion (type/intensity): Slight irritation, annoyance, stubbornness, rage, fury.

Appearance and muscle action:

- The medial ends of the eyebrows are pulled downward and drawn together, producing vertical wrinkles between them. This also pushes the upper eyelid, as well as the eye cover fold,

downward (corrugator supercilii, depressor supercilii, and procerus).

- The upper eyelid is raised, giving the eye a bulged, intense, staring quality (levator palpebrae superioris). The upper eyelid will then disappear under the lowered eye cover fold. The white above the iris, however, usually doesn't show, because of the lowered eye cover fold.
- The lower eyelid is sometimes raised (orbicularis oculi—palpebral portion).
- The nostrils become dilated and flared (dilator naris).
- Closed mouth: The lips are tightly pressed together (mentalis and orbicularis oris—outer portion). The red lips may or may not be tensed (orbicularis oris—red lip portion). The closed mouth version represents repressed anger. If the lips are pressed together without anger registering in the eyes and brow/forehead region, then this expression communicates concentration, determination, or physical exertion, not anger. The jaw may also be clenched (masseter and temporalis). The sides of the nose are compressed (nasalis—transverse portion; this muscle may also assist in pushing the upper lip downward).
- Open mouth: The mouth opening is *squared-off*, exposing the teeth and usually the gums (levator labii superioris and/or levator labii superioris alaeque nasi, and labial platysma and/or depressor labii inferioris). The red parts of the lips may then be tensed and inverted while the mouth remains open (orbicularis oris—red lip portion). The jaw may be clenched or dropped open in the open-mouth version. This version represents a verbal, nonrestrained, assault (yelling) type of anger. The mouth also assumes this open position during nonangry speech or shouting (the upper face must then not register anger).
- The angles of the mouth may be pulled medially (with the mouth either closed or slightly open), but the red lip portions of the lips must also be tensed as well in order to express anger (incisivus labii superioris and inferioris, and orbicularis oris—red lip portion).

To be unambiguous, anger must ideally be expressed in all three facial regions—the brows/forehead, eyes, and mouth. Horizontal skin wrinkles do not appear on the forehead during the expression of anger. During anger, blood pressure is increased, the face may redden, veins on the forehead and neck become engorged and pronounced, breathing is increased or completely halted, and the body becomes tensed overall. The entire head may also be thrust forward. Anger may increase gradually or hit maximum intensity immediately. Conversely, it may taper off slowly and then linger for a long time, or it may end abruptly.

Disgust/Contempt

DISGUST **Variations of the basic emotion** (type/intensity): Dislike, annoyance, aversion, repulsion, nausea.

Appearance and muscle action:

- The middle portion of each side of the upper lip is pulled upward *with* the skin on the bridge and sides of the nose being wrinkled (levator labii superioris alaeque nasi) or *without* the nose skin wrinkling (levator labii superioris). In both cases, the front of the cheeks are raised and bulged, and wrinkles develop below the lower eyelid. Extreme contraction of these muscles will part the lips by raising the upper lip, thereby exposing the upper teeth. When the levator labii superioris alaeque nasi contracts, the medial ends of the eyebrows are lowered by the *automatic simultaneous contraction* of the procerus. The eyebrows are not pulled together because the corrugator supercilii does not automatically contract in this case. Because of this automatic action, the upper eyelid is pushed downward over the iris by the descending eyebrow. And because the lower eyelid is pushed upward by the rising cheek, the eye opening becomes narrower. When the levator labii superioris alone contracts, the nasolabial furrow becomes angular and squared-off, and no movement takes place in the forehead, brow, and upper eyelids.
- Closed mouth: the lower lip may be raised and pressed against the upper lip (mentalis), and then it may be everted (lower labial tractors). The angles of the mouth may also be pulled downward (depressor anguli oris). The lips may be pressed together (orbicularis oris—outer portion), but the red lip portion must remain relaxed.
- Open mouth: The lower lip is pulled downward and may become protruded. Continued contraction will expose the lower teeth and then the gum (labial platysma). The upper lip remains retracted by the levator labii superioris or the levator labii superioris alaeque nasi, and the angles of the mouth may remain pulled downward by the depressor anguli oris. With the mouth open, the chin is often raised, pushing the middle of the lower lip upward (mentalis).

CONTEMPT **Variations of the basic emotion** (type/intensity): Disapproval, disrespect, derision, snobbery, scorn, disdain, loathing.

Appearance and muscle action:

- The middle portion of *one side only* of the upper lip is raised, producing a sneer (levator labii superioris and, less commonly, levator labii superioris alaeque nasi—both unilaterally). The lips on the side of the contraction may be-

come slightly parted. When the levator labii superioris alaeque nasi contracts unilaterally, skin wrinkles form on that side of the nose only.
- The corners of the mouth are pulled *straight back* (posteriorly, not laterally) and dimpled, on both sides or on one side only (buccinator).

Disgust and contempt are closely related yet distinct, and are grouped together.

Disgust often blends with anger and surprise. It is brought about by the actual experiencing of unpleasant sights, tastes, smells, or tactile experiences, or just by the thought of them. Sticking the tongue out, as in an attempt to remove undesired matter from the mouth, is an extreme form of disgust. Vomiting is the ultimate disgust reaction.

Contempt is the expression of condescension toward people, with a feeling of superiority felt, or hoped for, by the expresser. The head may be tipped back so the eyes look down at the other person. In this position, the nose is raised and the upper eyelids are lowered.

Interest/Excitement

Variations of the basic emotion (type/intensity): alertness, brightness, attentiveness, expectancy and anticipation.

Appearance and muscle action:
- The eyebrows are raised, producing horizontal wrinkles across the entire forehead (frontalis—both medial and lateral portions).
- The eyebrows may be pulled together (in either their normal or raised positions), creating vertical furrows between them (corrugator supercilii).
- The mouth is open and may be relaxed or rounded and pursed (incisivus labii superioris and inferioris).
- The head may be advanced forward.

Interest/excitement is also characterized by a focused gaze with continuous eye tracking of the person or object of interest. Slight turning of the head so as to direct the ear toward the sound stimulus may also be present. Interest/excitement is the opposite of boredom, and often accompanies other emotions (happiness, fear). It is similar to surprise, but surprise is a very brief emotion. If the appearance of surprise lasts for an extended period of time, it is probably interest/excitement.

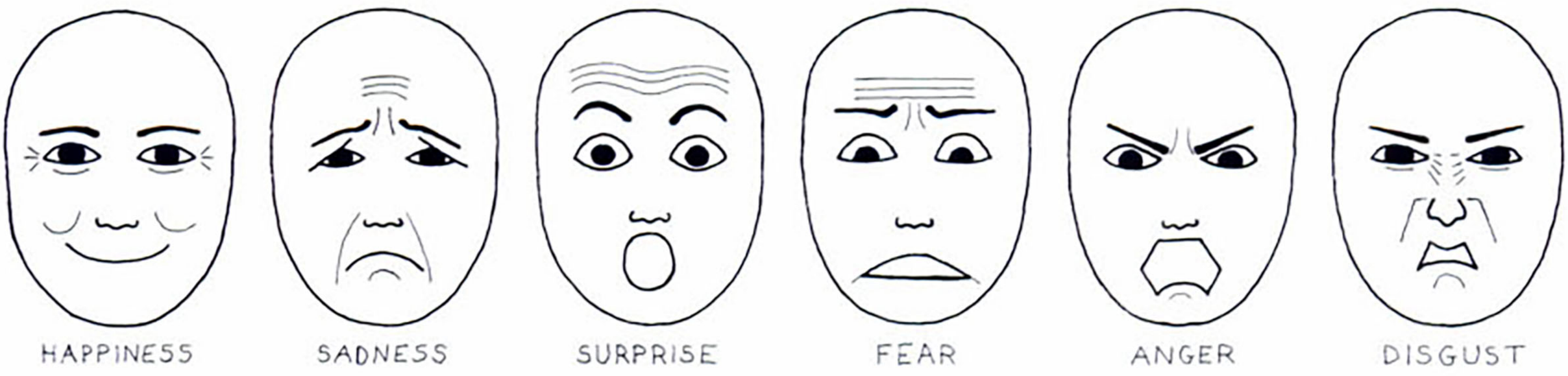
Pain/Distress

Variations of the basic sensation (type/intensity): Discomfort, ache, hurt, unbearable pain.

Appearance and muscle action:
- The eyes are completely and tightly closed for long periods of time; the cheeks are raised (orbicularis oculi—both orbital and palpebral portions).
- The eyebrows are pulled together and downward (corrugator supercilii, procerus, depressor supercilii).
- The mouth is usually wide open, and the lips are squared-off in preparation for crying or screaming. The angles of the mouth are pulled outward and downward (upper labial tractors, labial and nodular platysma).
- The mouth may be tightly pressed together, and the jaw tightly clenched (orbicularis oris—outer portion, mentalis, nasalis—transverse portion, temporalis, masseter).
- High skin ridges appear on the neck (all three parts of the platysma).

Pain/distress is usually characterized by intense muscular contraction. It is often accompanied by sadness, crying, or screaming.

Author's note: The complex subject of what actually constitutes the emotions, and their expression on the face, is still under much discussion in the psychological literature.

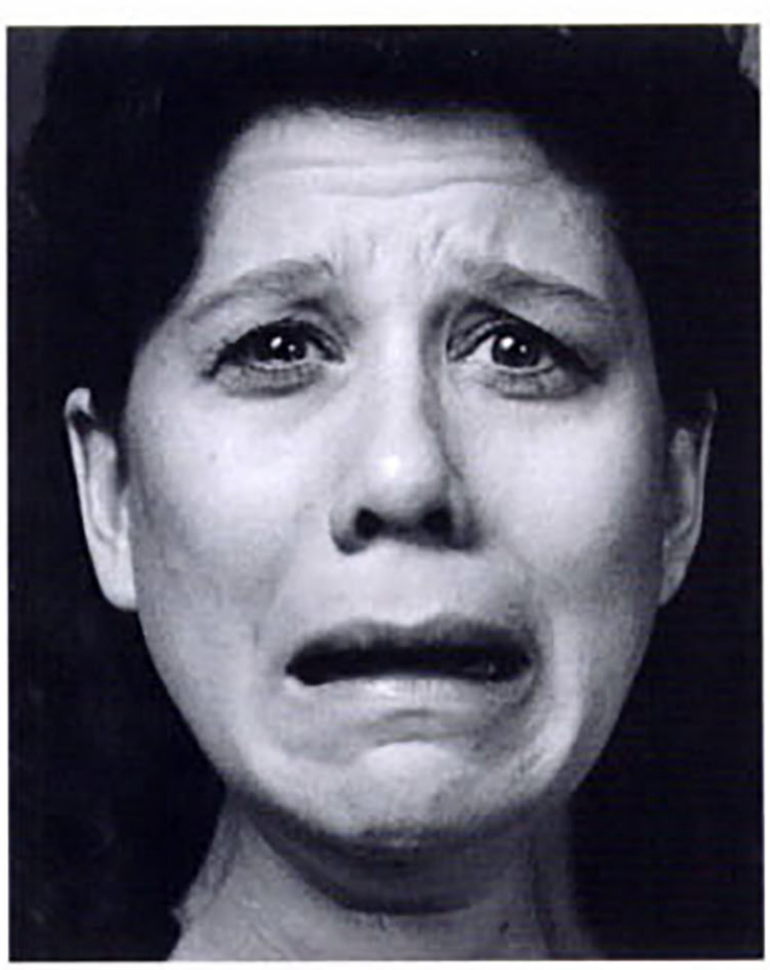


Neutral

Happiness—closed mouth

Happiness—open mouth

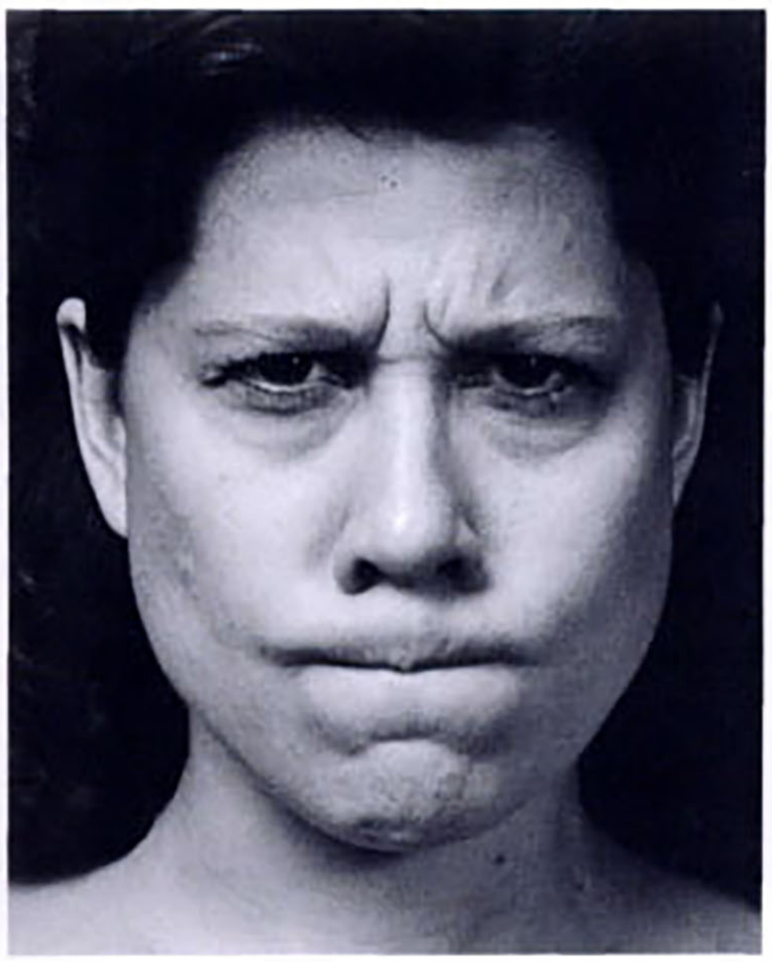
Sadness—closed mouth



Sadness—open mouth

Surprise

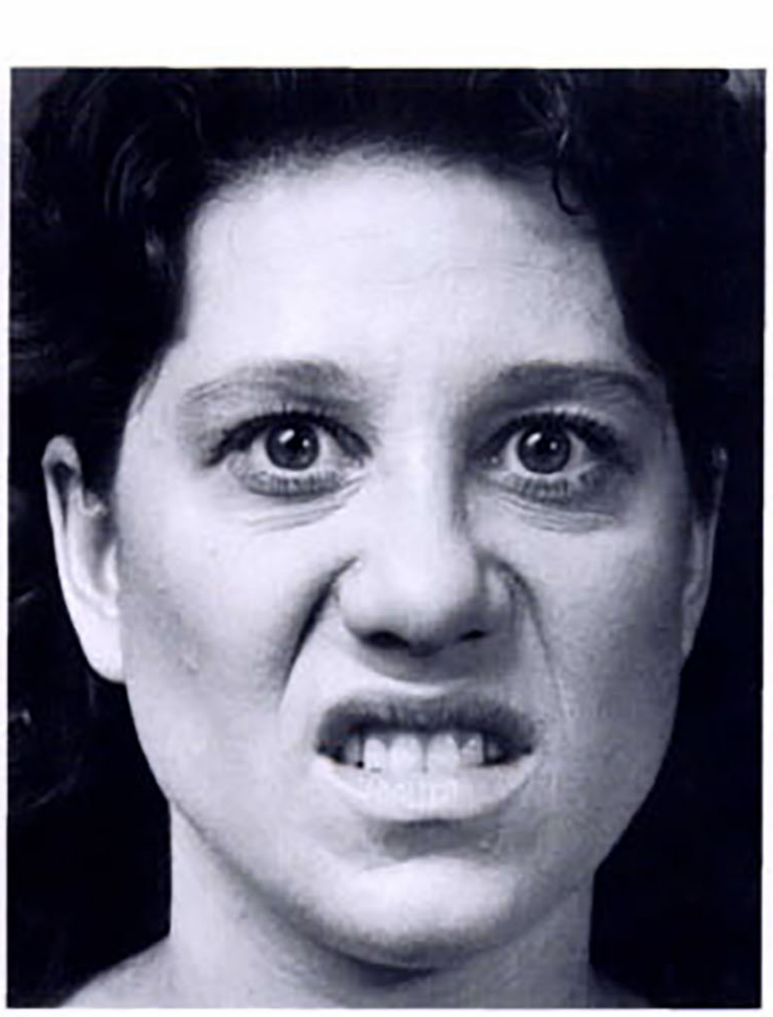
Fear



Anger—closed mouth

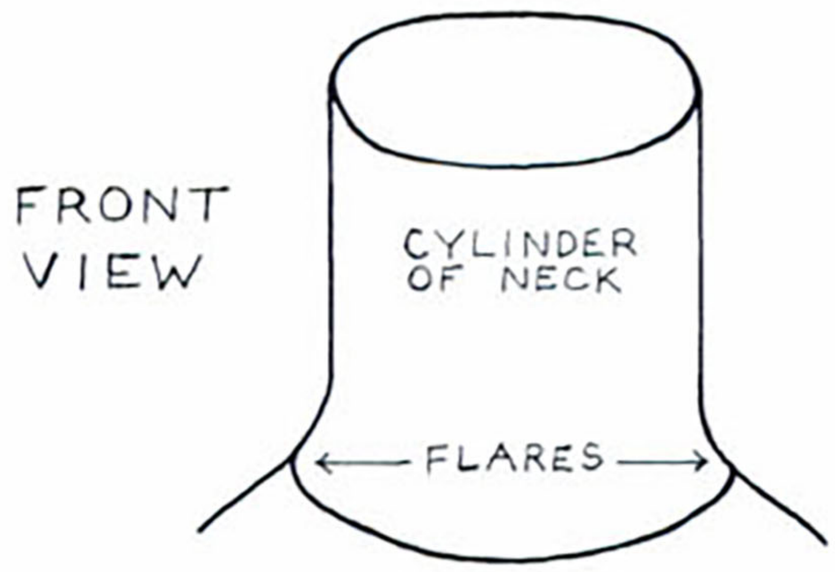
Anger—open mouth

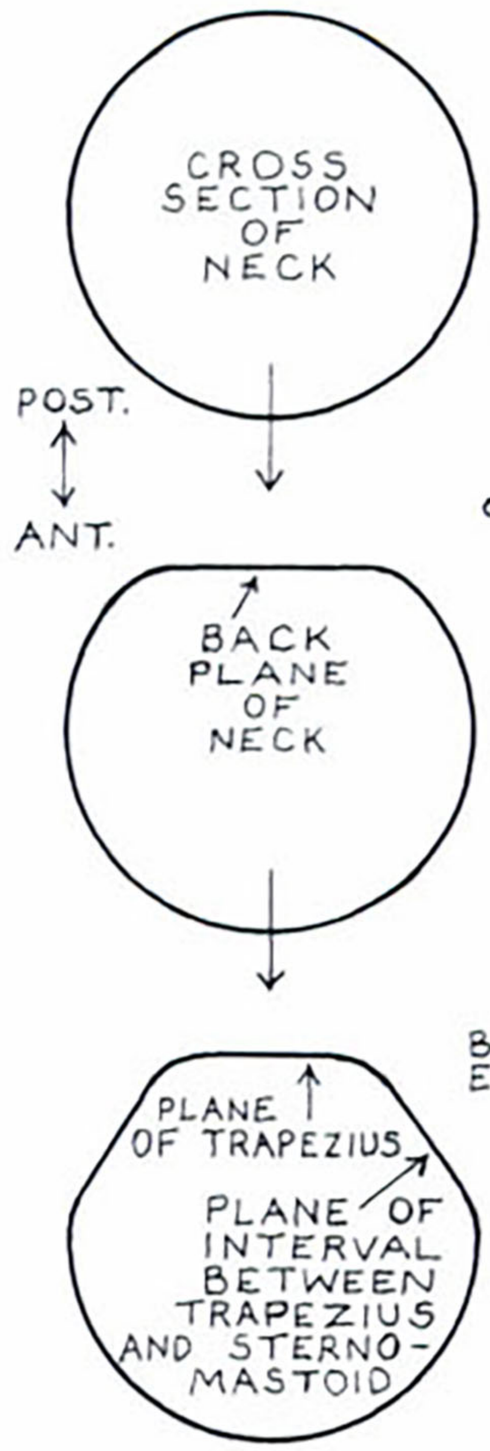
Disgust—Levator labii superioris alaeque nasi

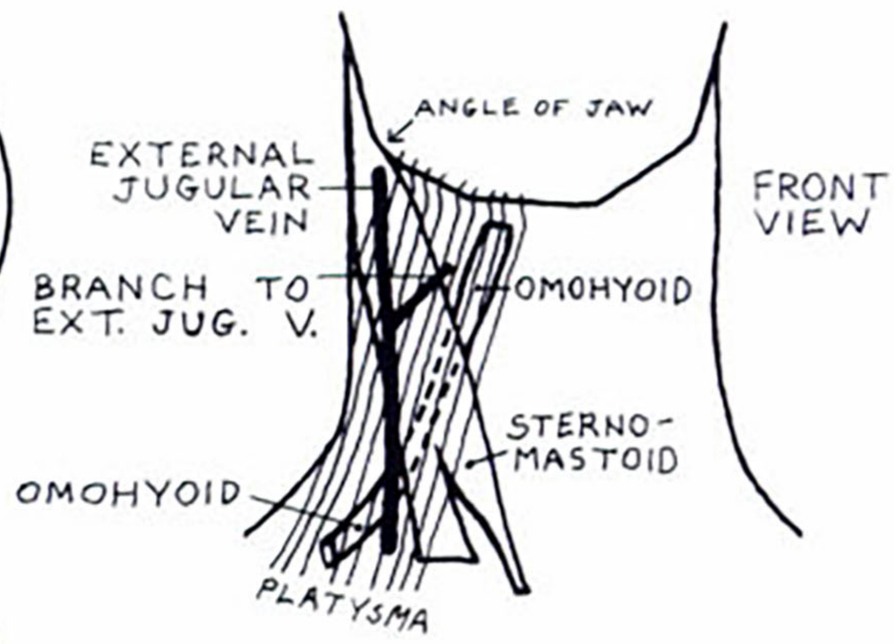


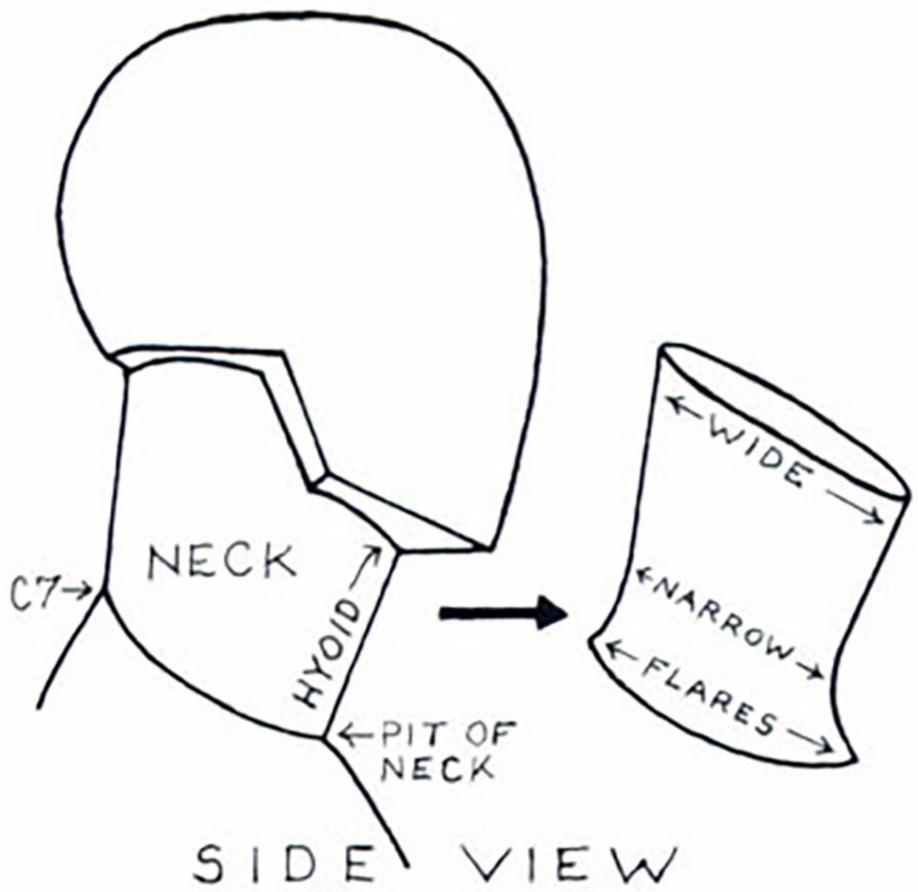
Disgust—Levator labii superioris

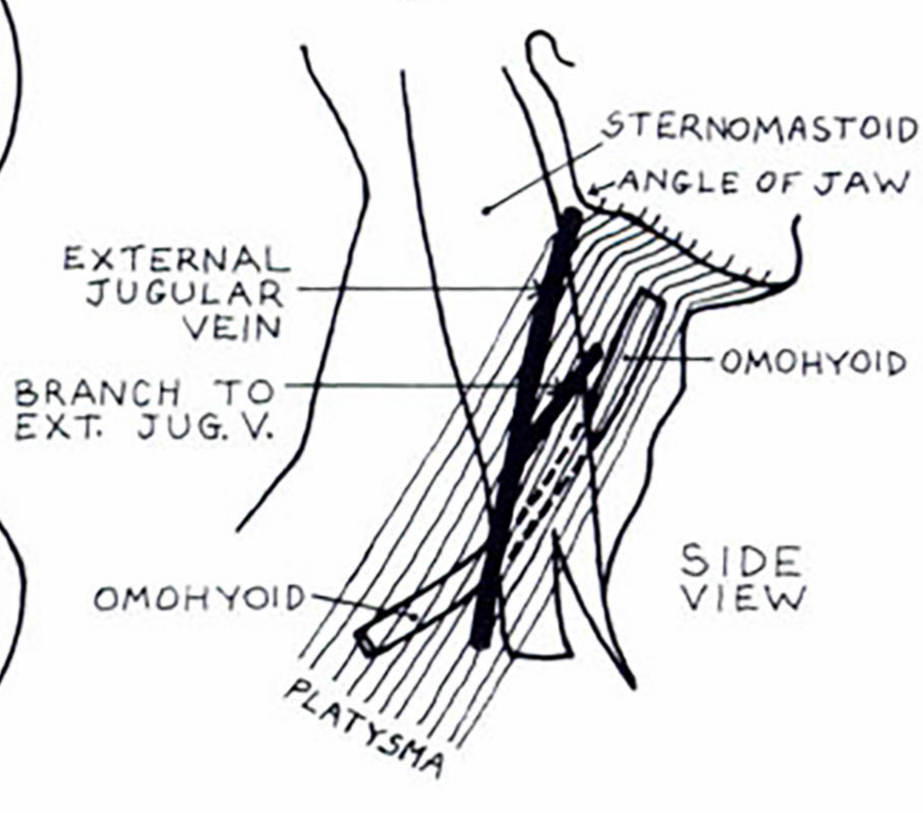
Contempt


FRONT VIEW
CYLINDER OF NECK
FLARES


CROSS SECTION OF NECK
POST.
ANT.
BACK PLANE OF NECK
PLANE OF TRAPEZIUS
PLANE OF INTERVAL BETWEEN TRAPEZIUS AND STERNO-MASTOID


ANGLE OF JAW
EXTERNAL JUGULAR VEIN
BRANCH TO EXT. JUG. V.
OMOHYOID
STERNO-MASTOID
OMOHYOID
PLATYSMA
FRONT VIEW


C7
NECK
HYOID
PIT OF NECK
WIDE
NARROW
FLARES
SIDE VIEW


STERNOMASTOID
ANGLE OF JAW
EXTERNAL JUGULAR VEIN
BRANCH TO EXT. JUG. V.
OMOHYOID
OMOHYOID
PLATYSMA
SIDE VIEW

The *HEAD*, or caput, is ultimately simplified into a box, which most effectively conveys the orientation of its axes and planes (see Mass Conceptions). The front plane of the head, containing most of the features, is the most complex. The side plane is formed by the chewing muscles, or muscles of mastication (temporalis and masseter), along with the bony zygomatic arch.

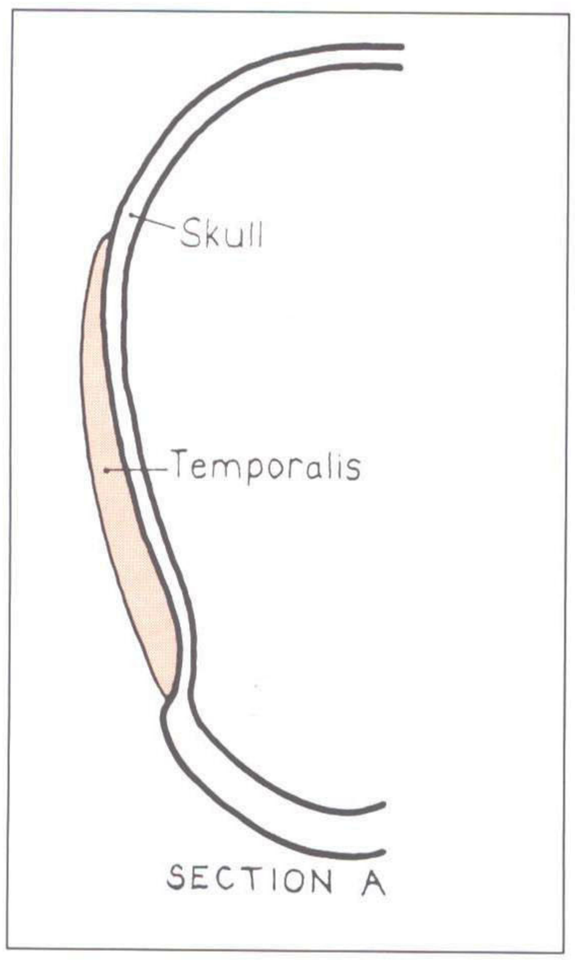
The **neck** can initially be visualized as a cylinder whose axis is directed downward and backward. Its back profile varies, being straight, convex, or concave (in side view). Except for the tendon of the sternomastoid, the front of the neck is directed *behind* the pit of the neck. The front of the neck descends lower than the back (the pit of the neck lies at a level lower than the spinous process of the seventh cervical vertebra). The back of the neck flows downward into the back of the thorax. The front and back of the neck, seen in side view, are not parallel, but converge inferiorly—the thickness from front to back is greater above (near the skull) than it is below (at the bottom of the neck). The sides of the neck appear roughly parallel.

The back surface of the neck tends to be flattened, while the remainder is round (see cross section). The cylinder of the neck flares outward at its base. When the head and neck are extended, the neck widens. When the head is rotated, the elongated interval on the side of the neck between the trapezius and sternomastoid mastoid becomes narrower on the side toward which the face is turned.

The side of the neck is layered with several anatomical structures: the platysma, sternomastoid, sternohyoid, omohyoid, and superficial veins. The occasionally seen, subtle omohyoid, whenever it pops up briefly, is clearly transverse to the thick, prominent sternomastoid, which lies on top of it (they form an X). The platysma, lying on the front and sides of the neck, tends to show up as numerous sharp, thin ridges when contracted, whereas the omohyoid shows up on the surface as a single, wider, rounder relief. The omohyoid and the strip of the platysma directly over it have roughly the same direction and inclination. A vein, lying just under the platysma, usually runs parallel to the omohyoid as it passes over the surface of the sternomastoid, but at a superior level. Because of the variability of veins in general, this neck vein may lie at other levels. The vein appears as a smaller, more cylindrical tube than the wider omohyoid, usually when the blood pressure in the head and neck region is increased. Because the omohyoid is normally seen only when speaking, it does not stay visible for a long time, but pops up momentarily. The forms of the platysma and the vein are maintained for a slightly longer period of time.

The superficial medial edge of the stringy platysma lies lateral to the wider and thicker sternohyoid; inferiorly, the sternohyoid passes *under* the sternomastoid, whereas the platysma passes *over* it.

Ma *Masseter* **Mal** *Malaris* **OOc** *Orbicularis oculi* **Te** *Temporalis* **ZA** *Zygomatic arch*



Temporalis

ORIGIN Entire temporal fossa on the side of the skull and the deep surface of the temporal fascia covering the muscle.

INSERTION Apex and deep surface of the coronoid process of the mandible (jaw bone) and into the front edge of the ramus of the mandible almost as far down as the last molar.

ACTION Lifts the mandible, which closes the jaw; the posterior fibers pull the jaw backward. The temporalis holds the jaw closed when the head is upright, and it clenches the teeth for chewing.

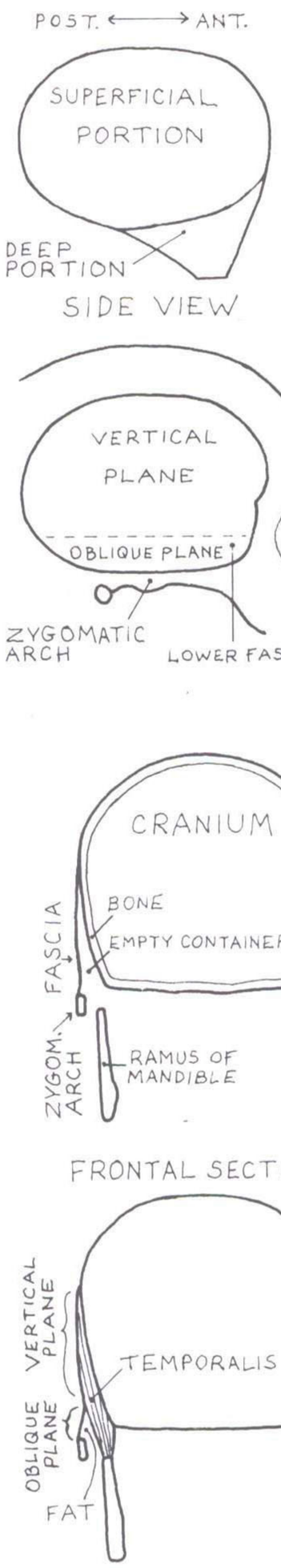
STRUCTURE The temporalis is a flat, fan-shaped muscle, thin at its margin, that fills the depression on the side of the skull. The side of the skull (the area of origin of the temporalis) and the inner surface of the temporal fascia (which covers the temporalis) form a flattened container from whose inside surfaces the temporalis originates. The fibers of the temporalis converge into a strong tendon deep to the zygomatic arch.

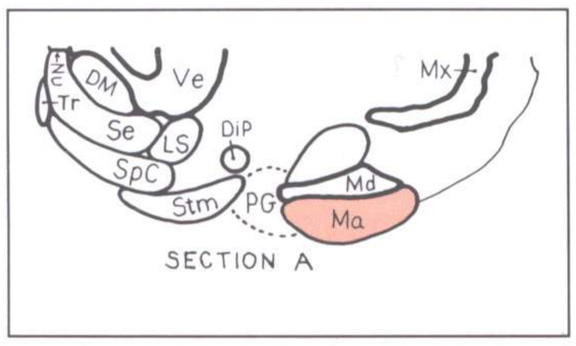
The superficial portion of the temporalis produces a horizontal oval relief on the surface when seen. The anterior portion of the muscle may be slightly recessed from the outer bony portion of the orbit, which then becomes prominent. The posterior portion of the temporalis is usually covered by hair.

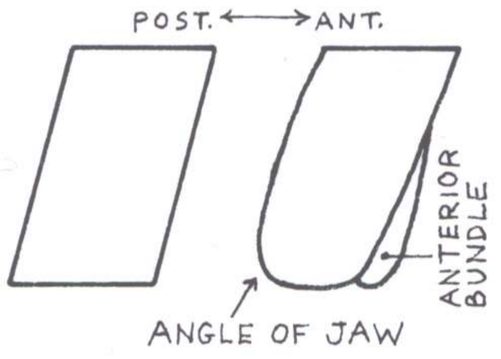
The **temporal fascia** is a strong, dense layer of fascia that lies on top of the temporalis, attaching to the skull just beyond the margin of the muscle (the muscle attaches to the inferior temporal line on the skull; the temporal fascia continues past it to attach to the superior temporal line). Inferiorly (a short distance superior to the zygomatic arch), the temporal fascia leaves the surface of the temporalis to attach to the upper edge of the zygomatic arch. At this point, a substantial accumulation of fat lies beneath the fascia (on top of the muscle). The plane of this lower fascia is basically oriented obliquely outward and upward, in contrast to the vertical orientation of the larger portion of the temporal fascia, which lies on the temporalis muscle belly. Because the plane of the lower fascia is directed slightly upward, it receives more light than the vertical temporalis. The lower fascia flows into the zygomatic arch, creating a single, rounded, horizontal form on the side of the cheek. There is usually no visible separation between the top edge of the zygomatic arch and lower portion of the fascia. The plane of the lower fascia gradually blends into the plane of the temporalis.

Because the lower portion of the fascia spans over to the zygomatic arch, the temporalis never appears to actually pass under the zygomatic arch. The bony zygomatic arch itself is usually not sharply defined. Only occasionally does it show clearly.

At the temple (posterior to the bony orbit of the eye and superior to the zygomatic arch), the temporalis is seen bulging when the jaw is closed (the belly is shortened and thickened) and sinking in when it is opened (the belly is stretched and thinned). When the jaw is fully opened, however, the condyle and ramus of the mandible move forward, compressing the fat and muscular tissue in front of them. This pushes the fat lodged under the zygomatic arch upward, which bulges the lower portion of the temporal fascia outward. The advancing mandibular condyle and compressed tissue also bulge the masseter muscle below the zygomatic arch outward (laterally), the net result being that the horizontal zygomatic arch becomes recessed between the fatty bulge above and the muscular bulge below. This is unusual, because stretched and elongated muscles always become thinner, increasing the projection of adjacent bony areas.







SIDE VIEW

Masseter

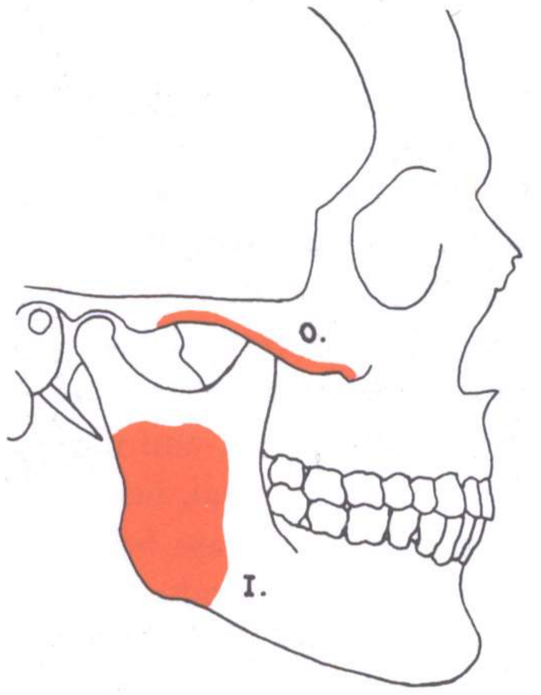
ORIGIN *Superficial part:* Anterior two-thirds of the inferior border of the zygomatic arch, continuing forward to the zygomatic process of the maxilla. *Deep parts:* Inner (deep) surface of the entire zygomatic arch.

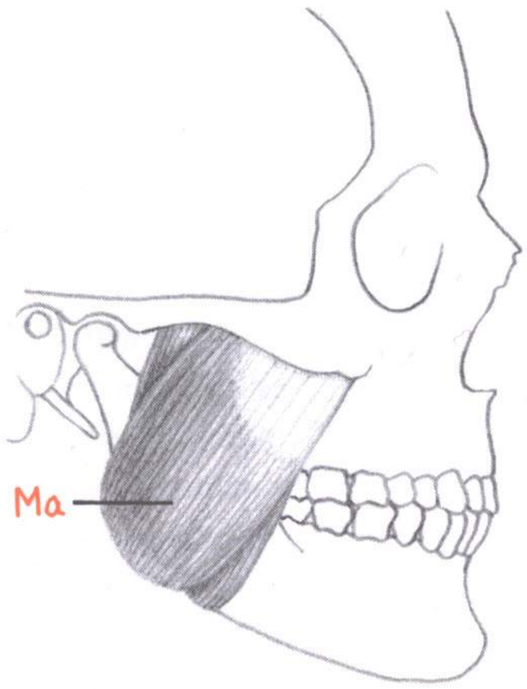
INSERTION Lateral surfaces of the coronoid process, ramus, and angle of the jaw.

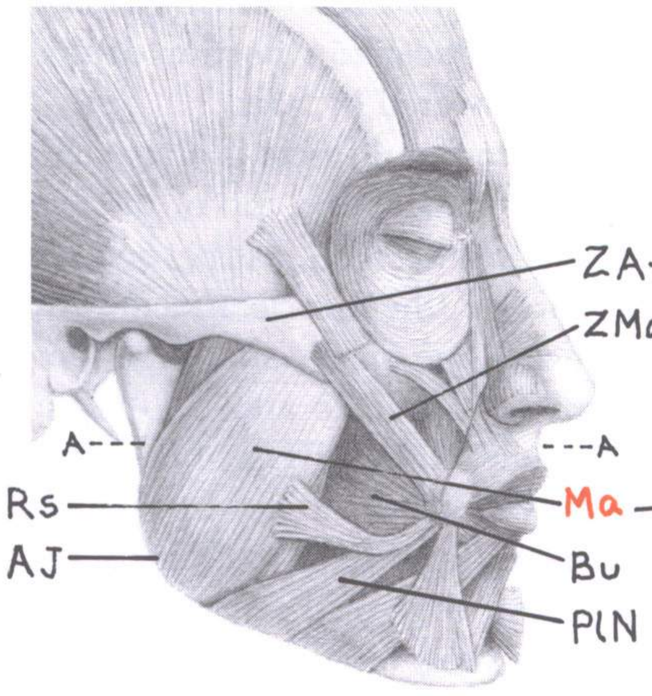
ACTION Closes the jaw by lifting the mandible; clenches the teeth for chewing.

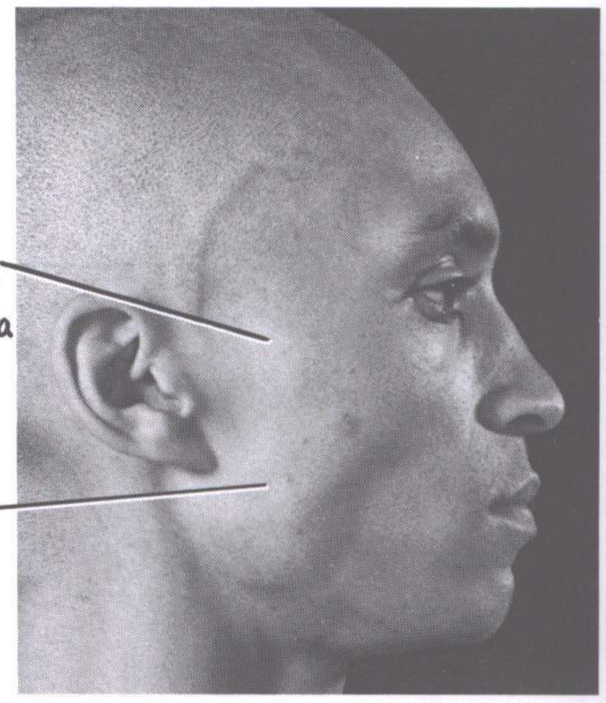
STRUCTURE The masseter is a thick quadrilateral muscle that lies obliquely on the side of the jaw. It is directed from the lower margin of the zygomatic arch and cheekbone downward and backward to the angle of the jaw. Only its superficial portion is seen. When clenching the teeth because of tension, or when chewing, the bulge of the masseter belly can be seen separating into several thin, elongated, parallel bundles, directed along the overall axis of the form of the muscle. The most anterior of these bundles shows up on the lower half of the front edge of the belly. The entire front edge of the muscle may be seen if the cheek fat is thin, whereas the back edge is not distinct as it is softened by the overlying parotid gland.

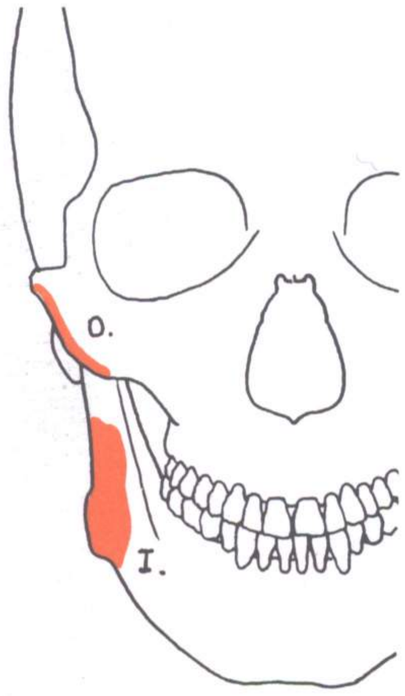
The surface planes of the masseters on both sides of the head usually converge slightly inferiorly, but may at times be parallel or even diverge inferiorly. The surface of the masseter may flow into the surface of the zygomatic arch (no separation), or the superior end of the masseter may be recessed slightly, leaving the lower edge of the zygomatic arch defined.

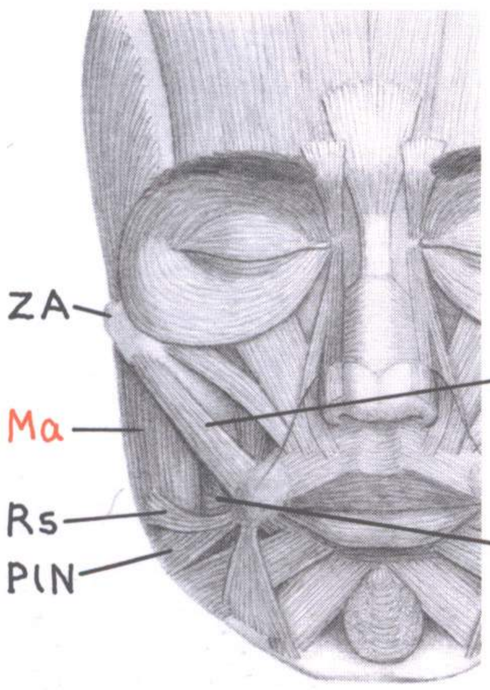


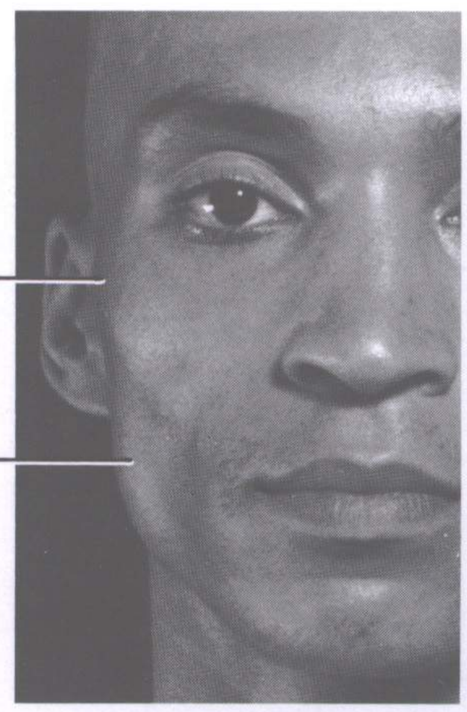




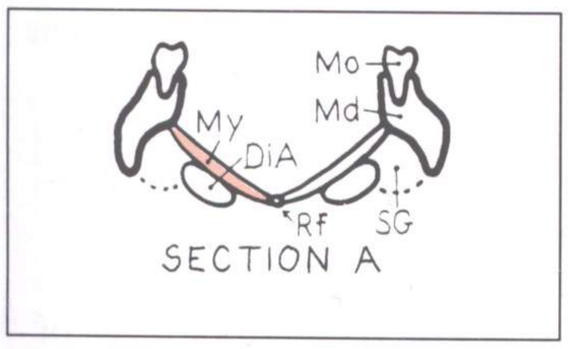


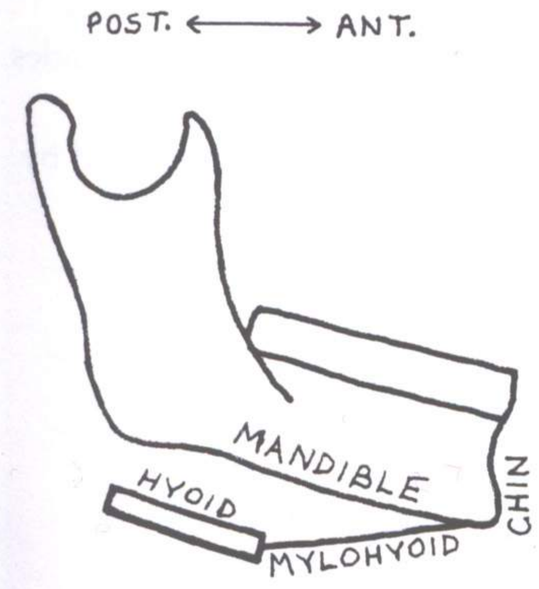






AJ *Angle of jaw* **Bu** *Buccinator* **DiA** *Digastric—anterior belly* **Hy** *Hyoid bone* **Ma** *Masseter* **Md** *Mandible* **Mo** *Molar* **Mx** *Maxilla* **My** *Mylohyoid* **PG** *Parotid gland*





Mylohyoid

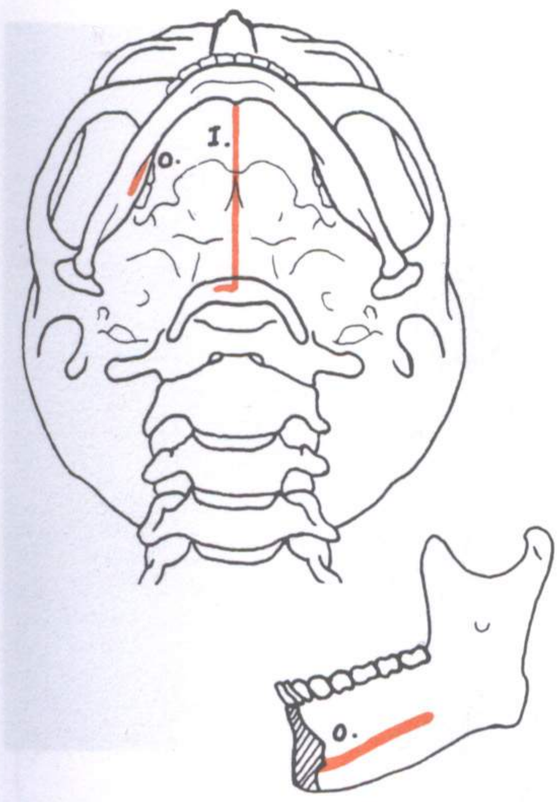
ORIGIN A line along the anterior three-quarters of the inner surface of the body of the lower jaw.

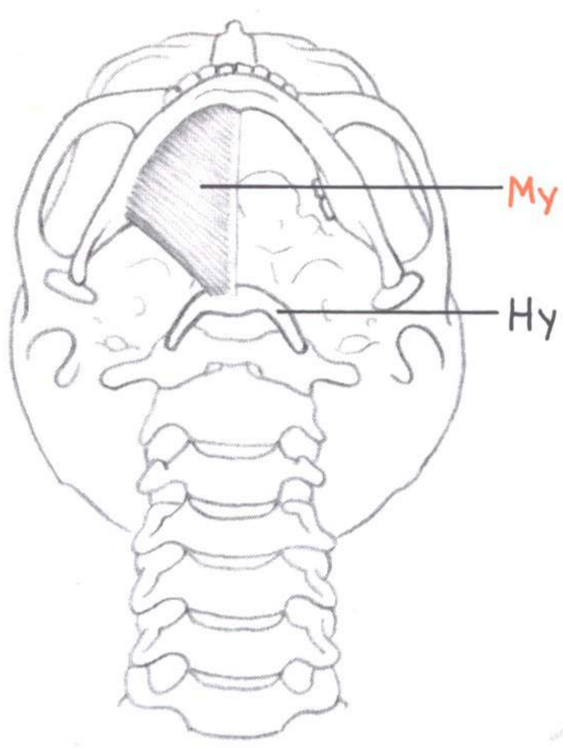
INSERTION A median tendinous line, or raphe (actually part of the mylohyoid itself), which passes from the midline at the bottom of the chin to the midline on the front of the hyoid bone. Most of the muscular fibers of the mylohyoid insert into this raphe (the fibers from the muscles of both sides meet here), while the most posterior fibers insert directly into the front surface of the hyoid bone.

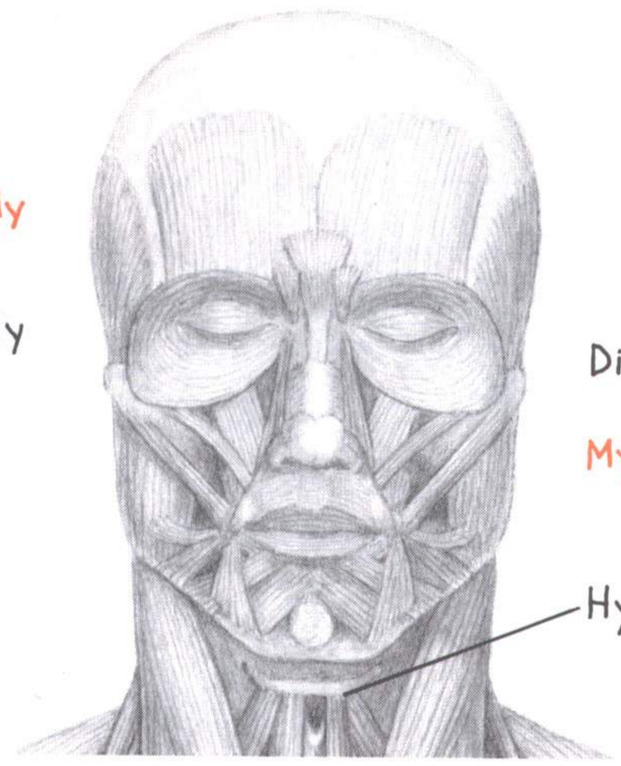
ACTION Lifts the floor of the mouth and the hyoid bone when swallowing.

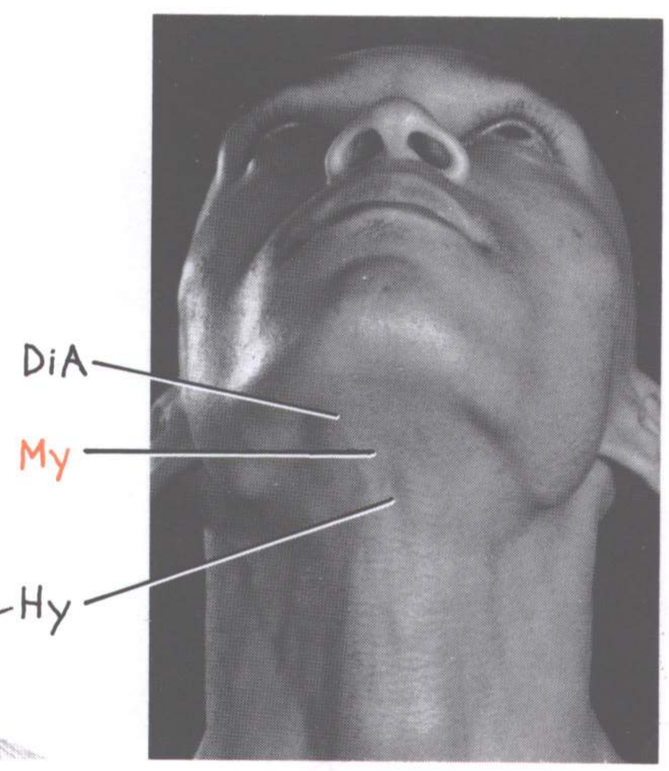
STRUCTURE The mylohyoid is a flat, sheet-like triangular muscle. The muscles of both sides span the bottom of the jaw and are upwardly recessed from the lower border of the body of the mandible at their lateral edges (their origins). The overlying anterior bellies of the digastric, submandibular glands, and fat join with the mylohyoids in creating the **bottom plane of the jaw.**

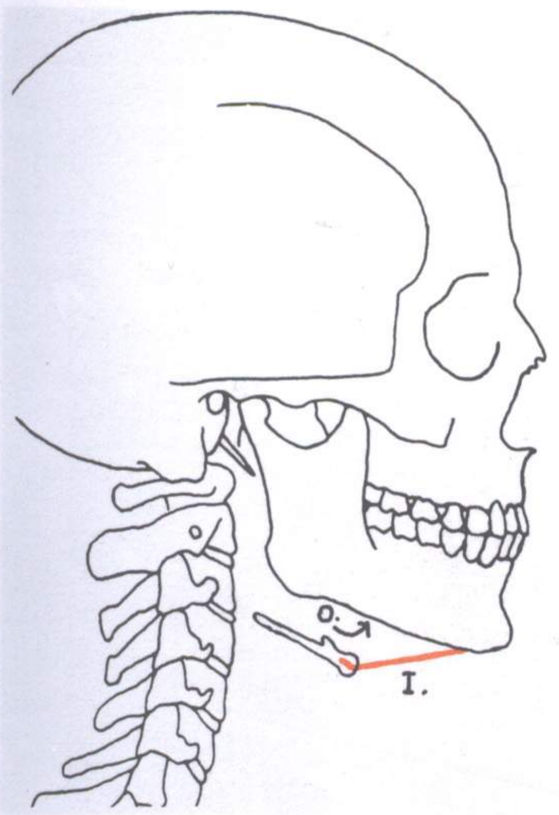
The mylohyoid of each side passes medially and *downward* to its insertion on the median raphe and hyoid bone. Looking at the side view of the bottom plane of the jaw, its profile (at the midline) passes backward and slightly downward (is almost *horizontal*), whereas the line of the bottom edge of the mandible passes backward and slightly upward (is *oblique*).

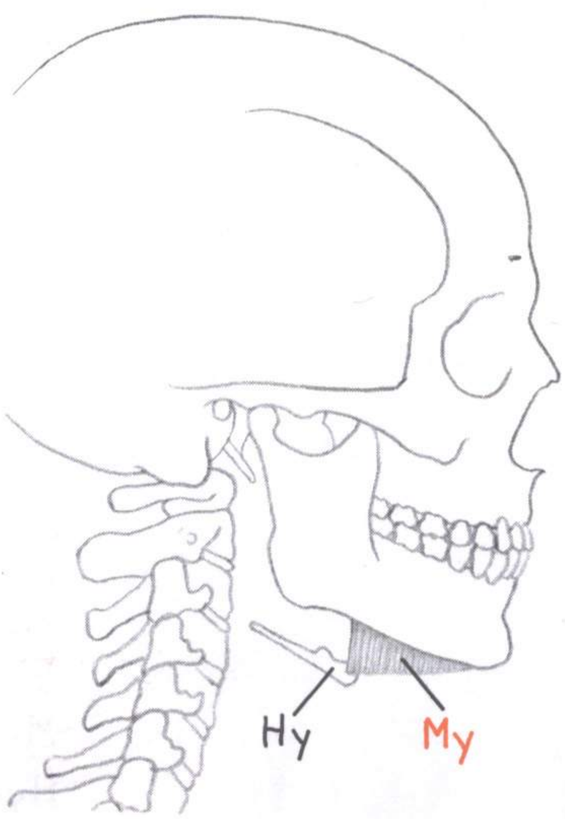


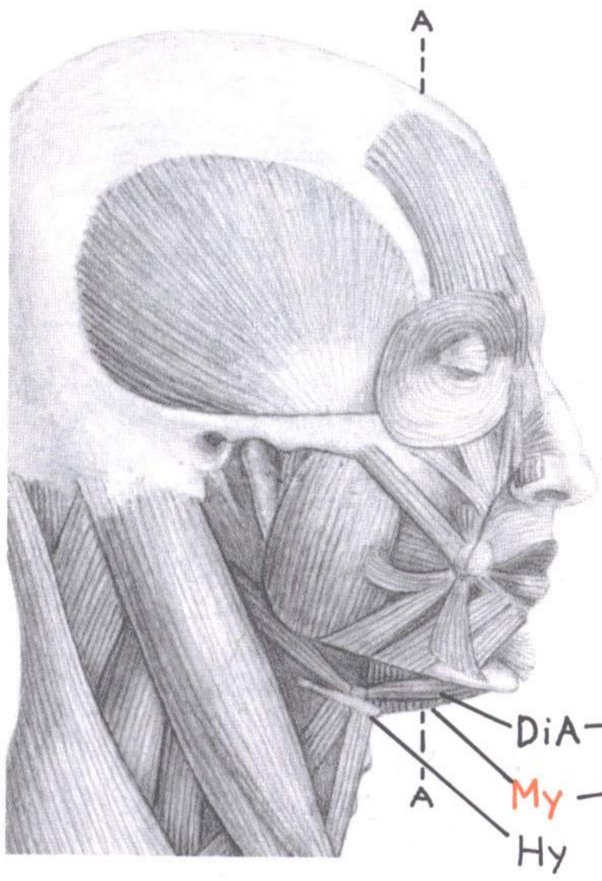


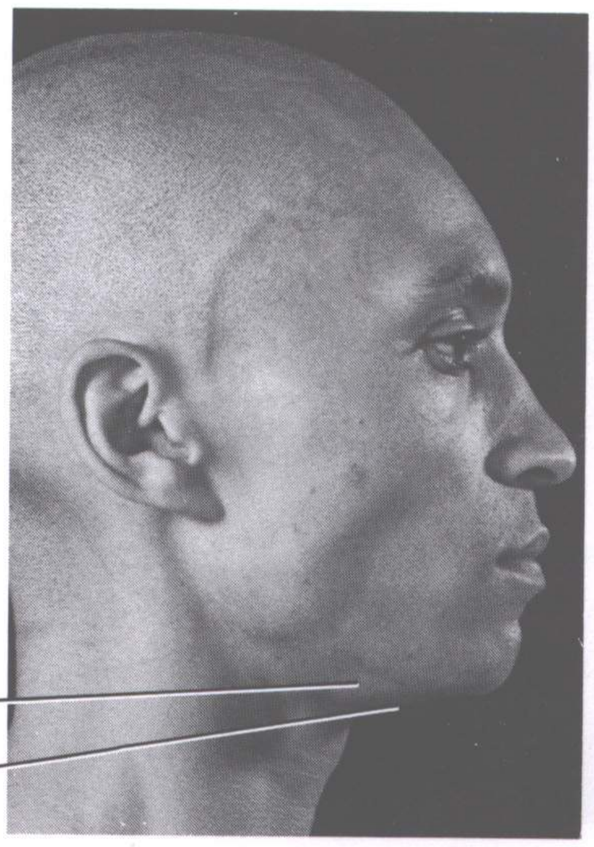




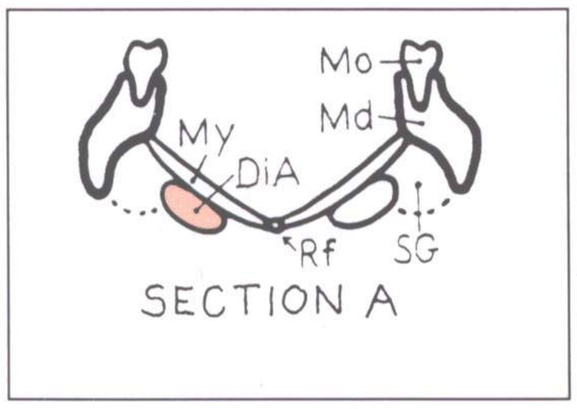


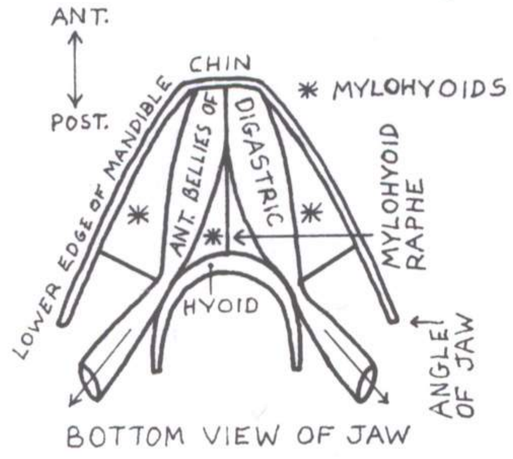






PlN *Platysma—nodular portion* **Rf** *Raphe* **Rs** *Risorius* **SG** *Submandibular gland*
ZA *Zygomatic arch* **ZMa** *Zygomaticus major*





Digastric
(Biventer Mandibulae)

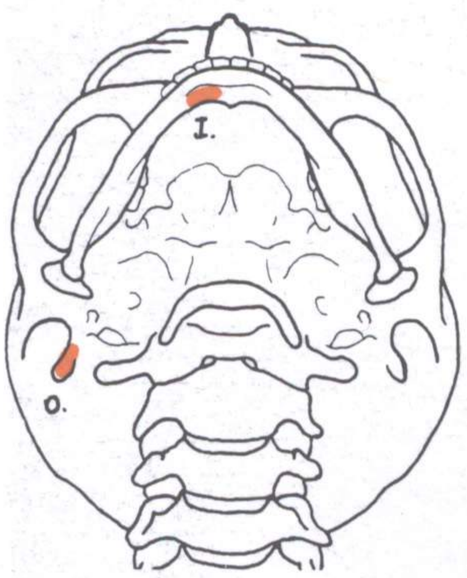
ORIGIN The mastoid notch on the bottom of the mastoid process of the skull.

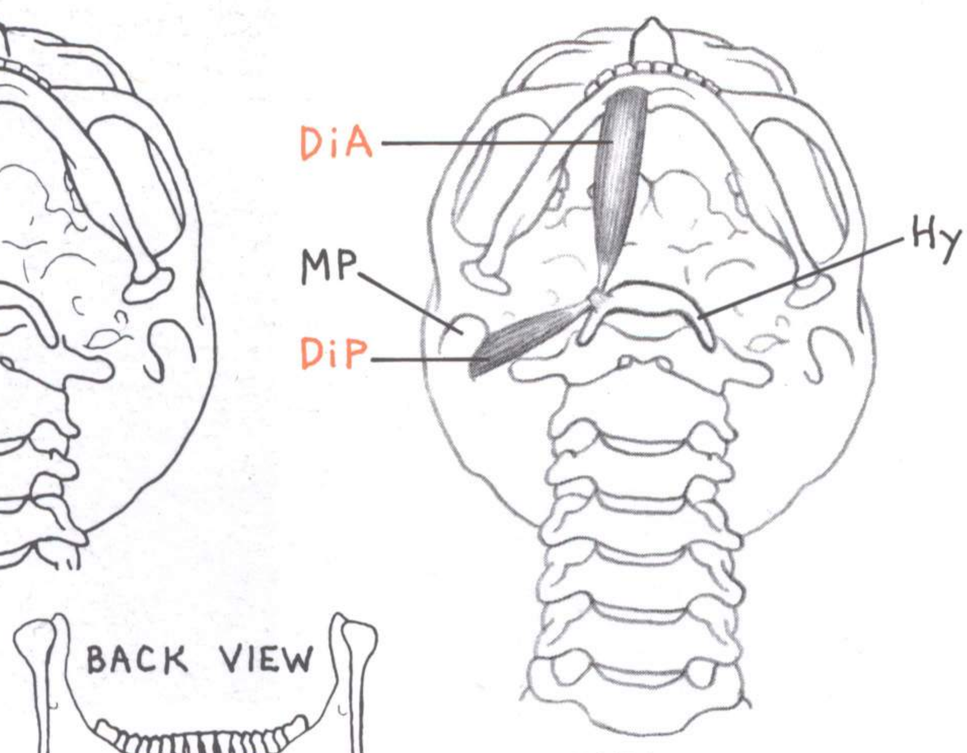
INSERTION The lower edge of the deep surface of the mandible behind the chin (just off the midline).

ACTION Opens the mouth by pulling the front of the lower jaw down; lifts the hyoid bone.

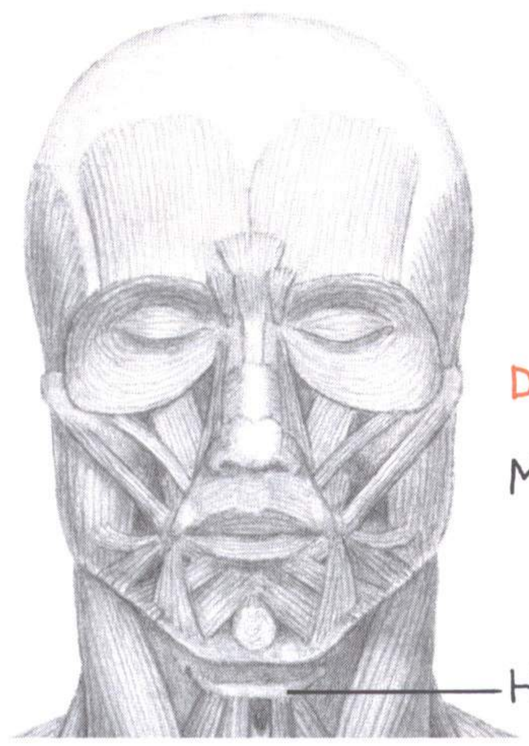
STRUCTURE The digastric consists of two bellies, an anterior and a posterior, that are connected end to end by a short, centrally located tendon. The tendon is hooked to the side of the body and greater horn of the hyoid bone by a fibrous sleeve through which it passes.

The anterior belly of the digastric is larger and thicker than the posterior belly. The anterior belly sometimes appears as a subtle elongated relief that is directed posteriorly and slightly laterally. It lies on the bottom plane of the lower jaw, on the surface of the mylohyoid muscle. When the head is extended, exposing the bottom of the jaw, the muscles of both sides can sometimes be seen diverging posteriorly from the chin. The posterior belly is covered by the parotid gland.

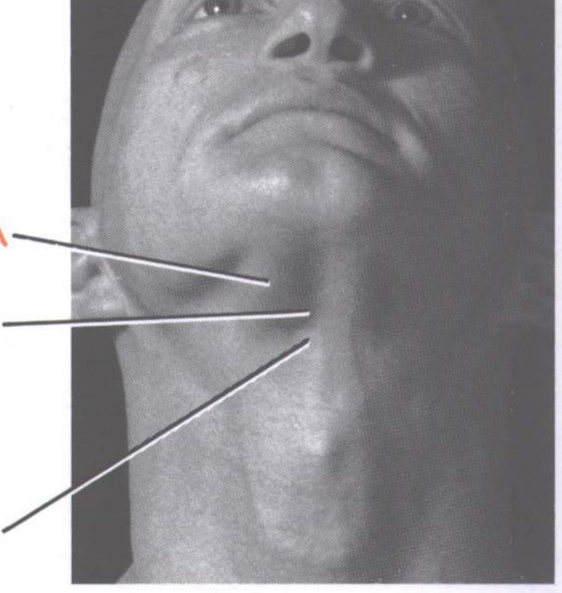


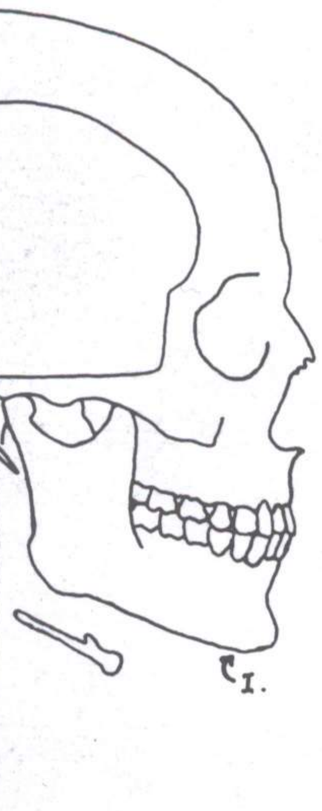


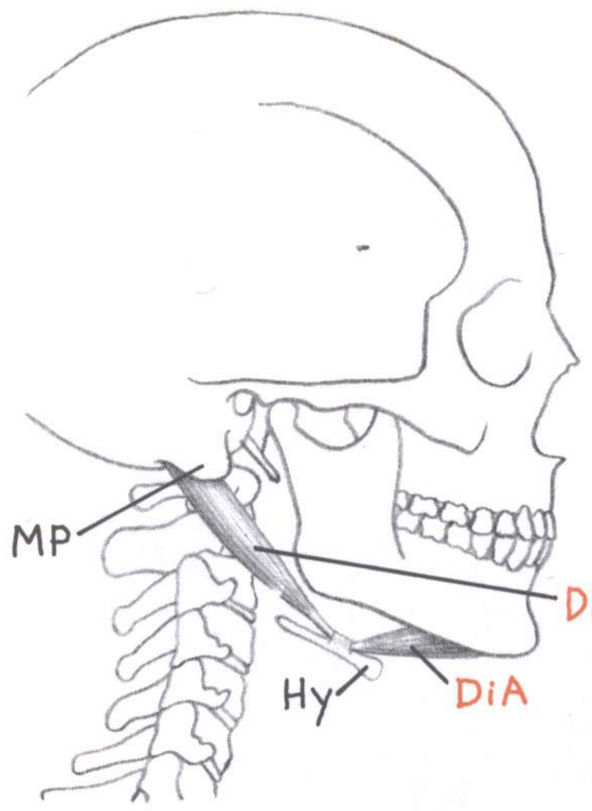
HEAD TIPPED BACK

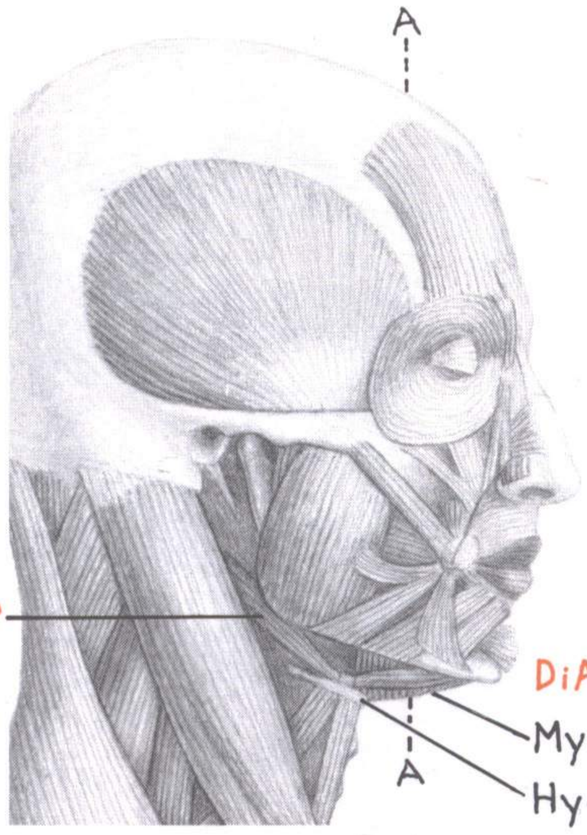


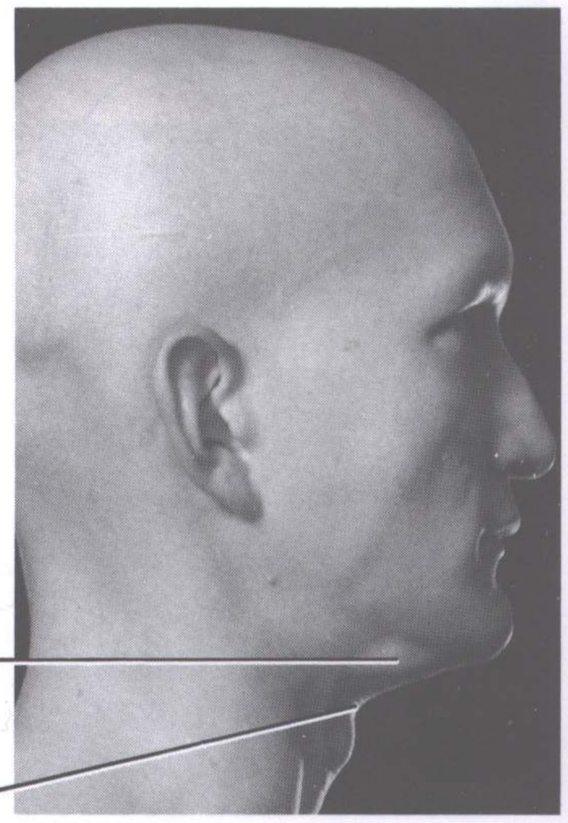
DIGASTRIC NOT VISIBLE



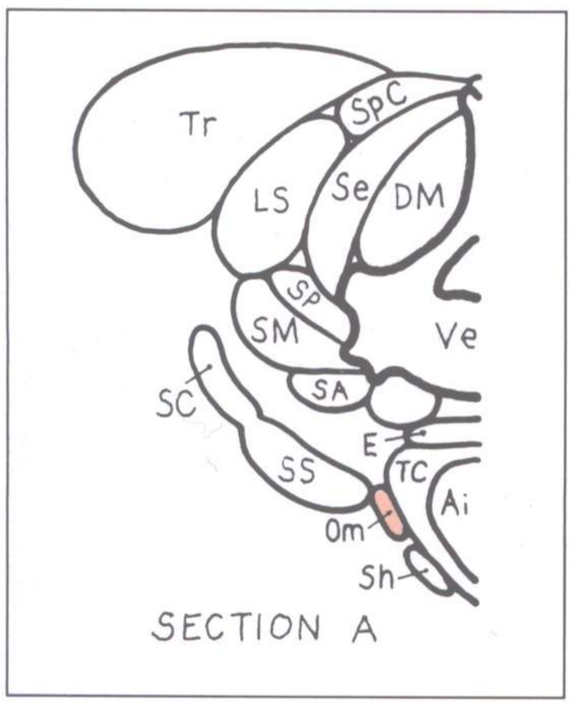








DiA *Digastric—anterior belly* **DiP** *Digastric—posterior belly* **Hy** *Hyoid bone* **LS** *Levator scapulae* **MP** *Mastoid process* **My** *Mylohyoid* **Om** *Omohyoid* **SC** *Sternomastoid—clavicular head*



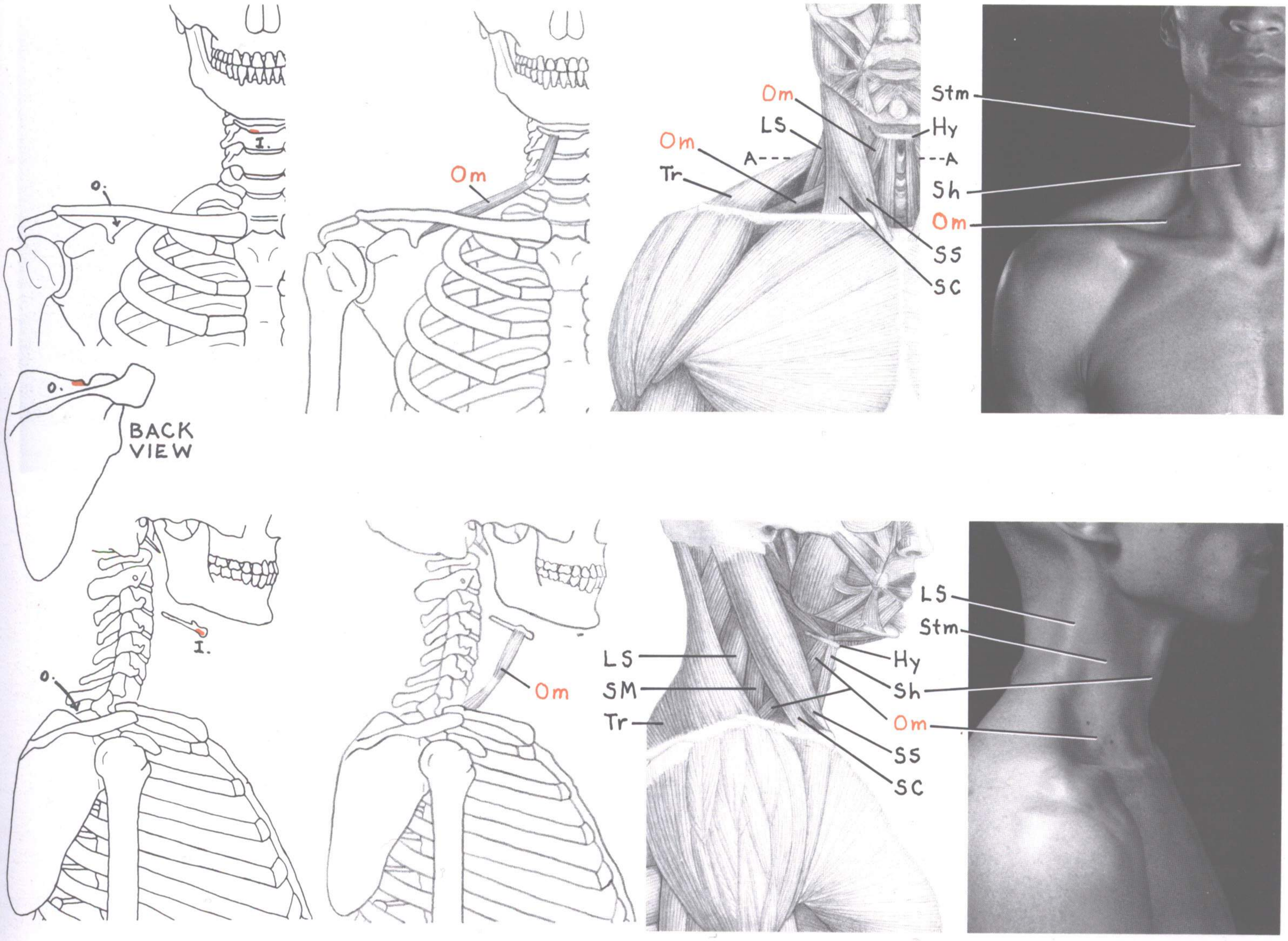
Omohyoid

ORIGIN A short line on the superior border of the scapula, just medial to the notch at the base of the coracoid process, and sometimes from a ligament that crosses this notch.

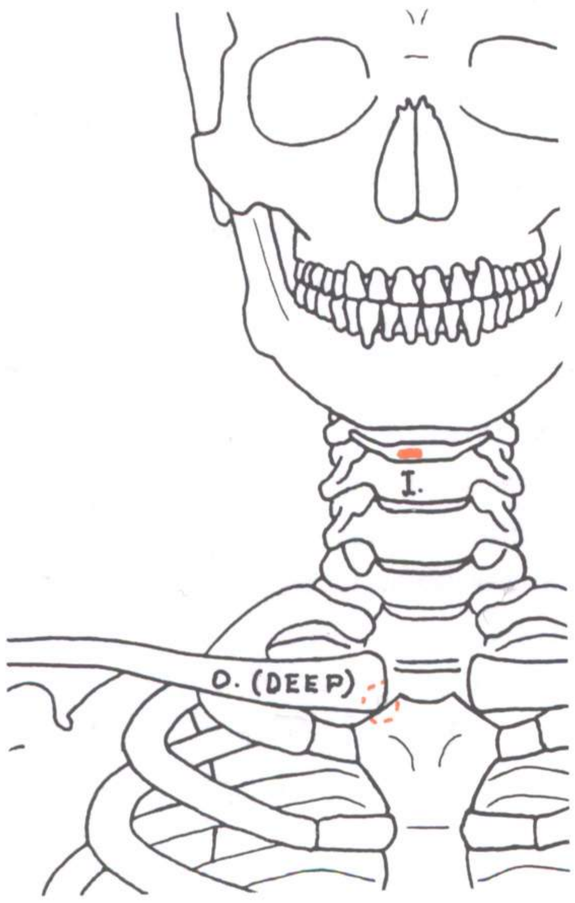
INSERTION Inferior border of the side of the body of the hyoid bone toward the front (just lateral to the insertion of the sternohyoid).

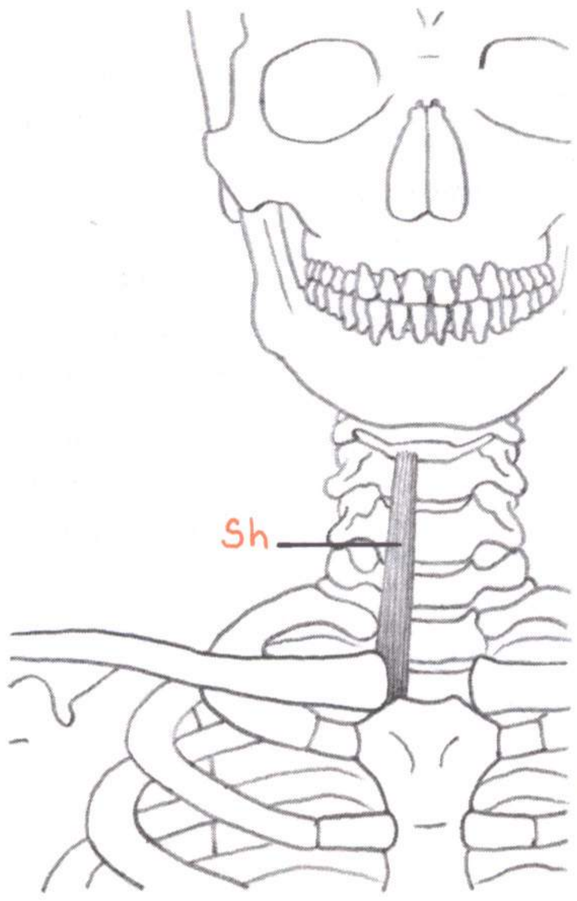
ACTION Pulls the hyoid bone down.

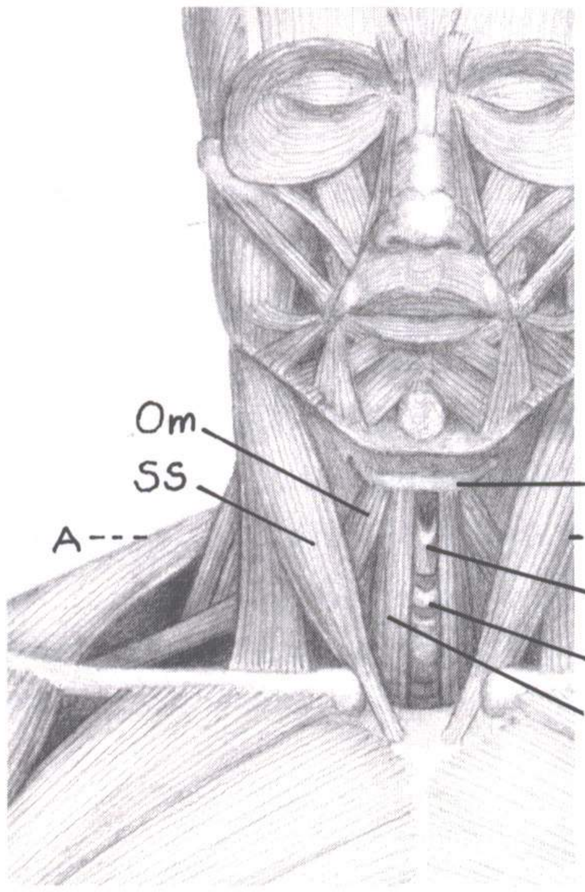
STRUCTURE The omohyoid consists of two narrow, flat bellies—a superior and an inferior—connected end to end by a short tendon. The tendon lies under the sternomastoid muscle. The omohyoid bends at this tendon as it ascends upward and forward on the side of the neck. The omohyoid is occasionally seen, part directly, part indirectly, when speaking, when the muscles on the bottom of the jaw are tensed or when the head is fully turned to one side. When contracted, it straightens between its two points of attachment, lifting the sternomastoid in the process. The tendinous portion beneath the sternomastoid is then seen as a thick, oblique, cordlike relief whose form is continued both superiorly and inferiorly by the now visible superficial bellies.

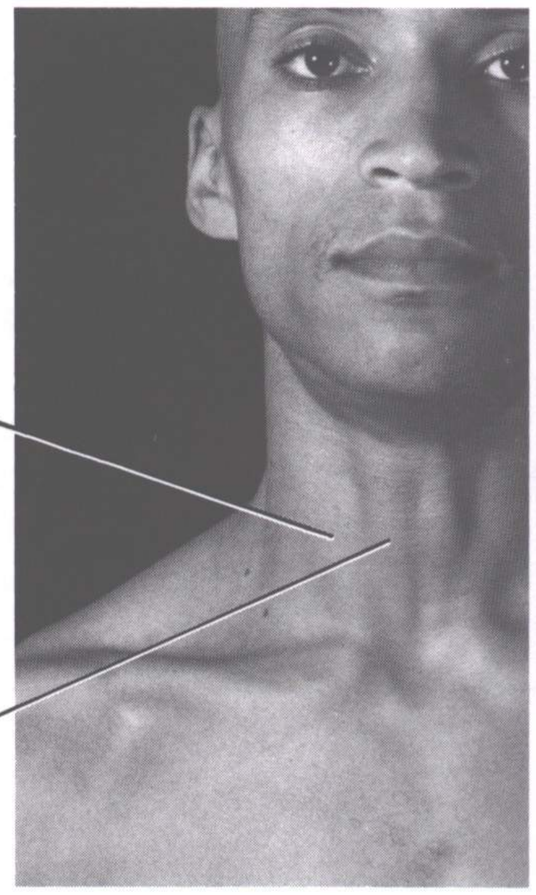


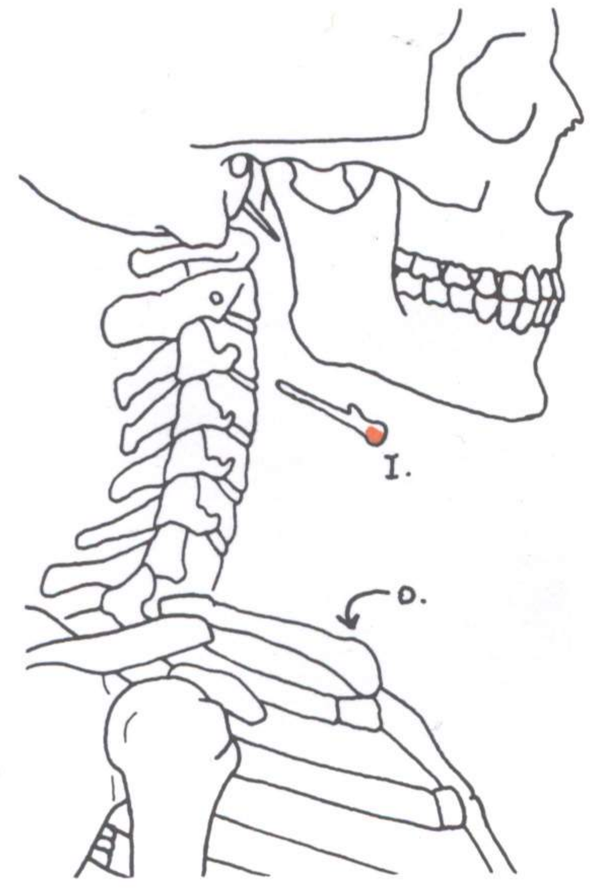
SG *Submandibular gland* **Sh** *Sternohyoid* **SM** *Scalenus medius* **SS** *Sternomastoid—sternal head*
Stm *Sternomastoid* **TC** *Thyroid cartilage* **Tr** *Trapezius* **Ve** *Vertebra*

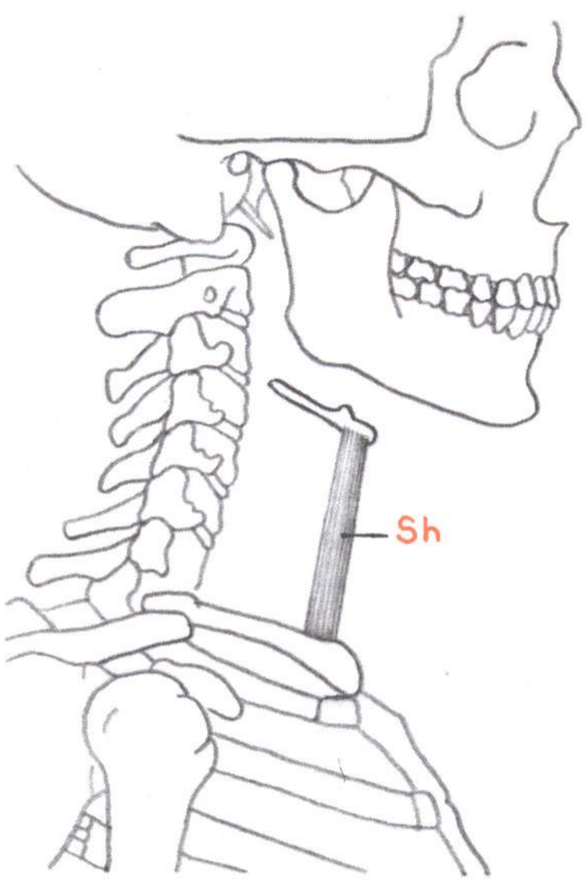


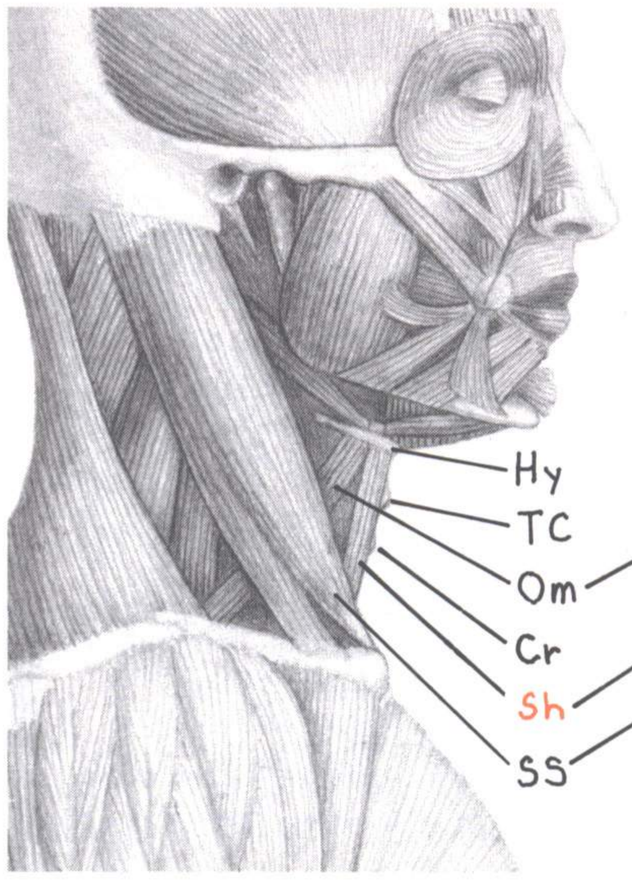


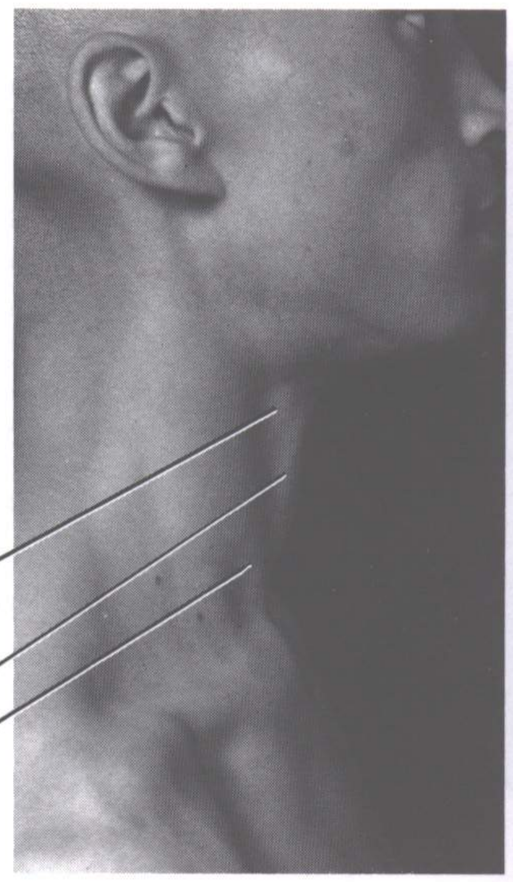




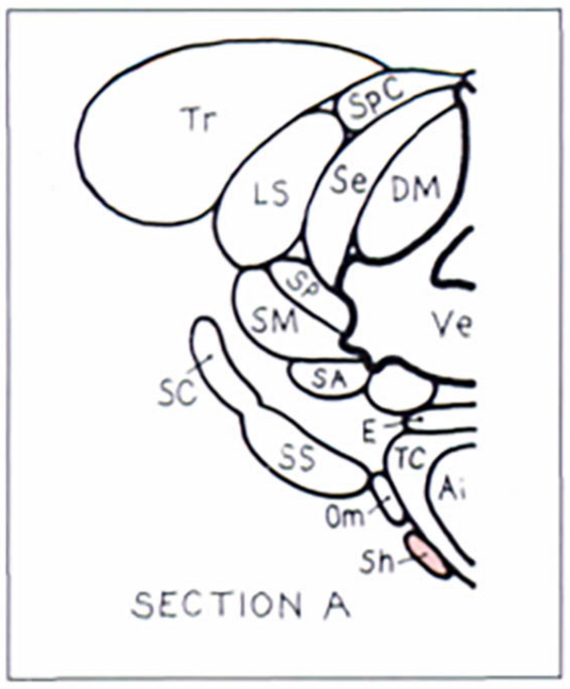




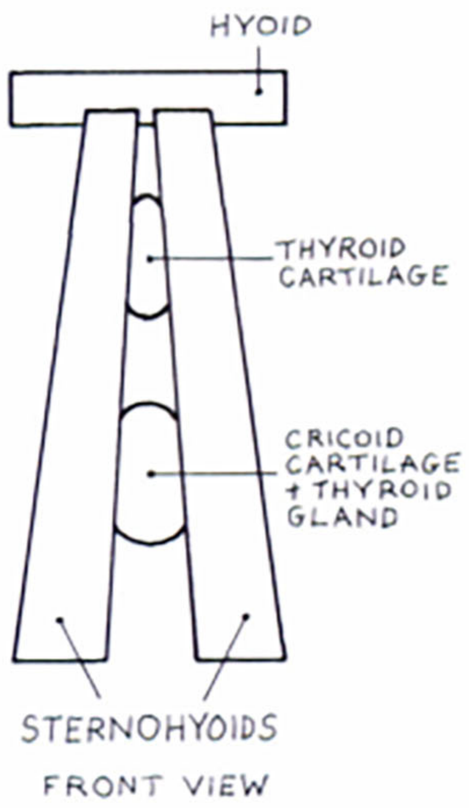




Cr *Cricoid cartilage* **Hy** *Hyoid bone* **Om** *Omohyoid* **Sh** *Sternohyoid*
SS *Sternomastoid—sternal head* **TC** *Thyroid cartilage*



SECTION A



STERNOHYOIDS
FRONT VIEW

Sternohyoid

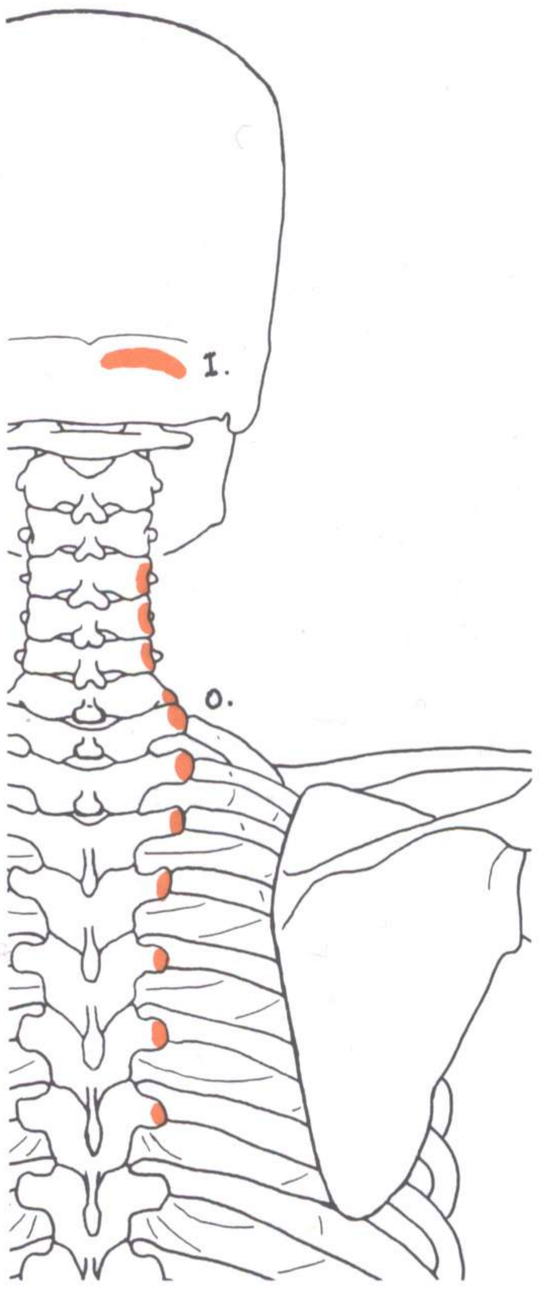
ORIGIN Posterior surface of the medial end of the clavicle; the upper lateral portion of the posterior surface of the manubrium of the sternum near the notch for the clavicle; and the ligament between these two bones.

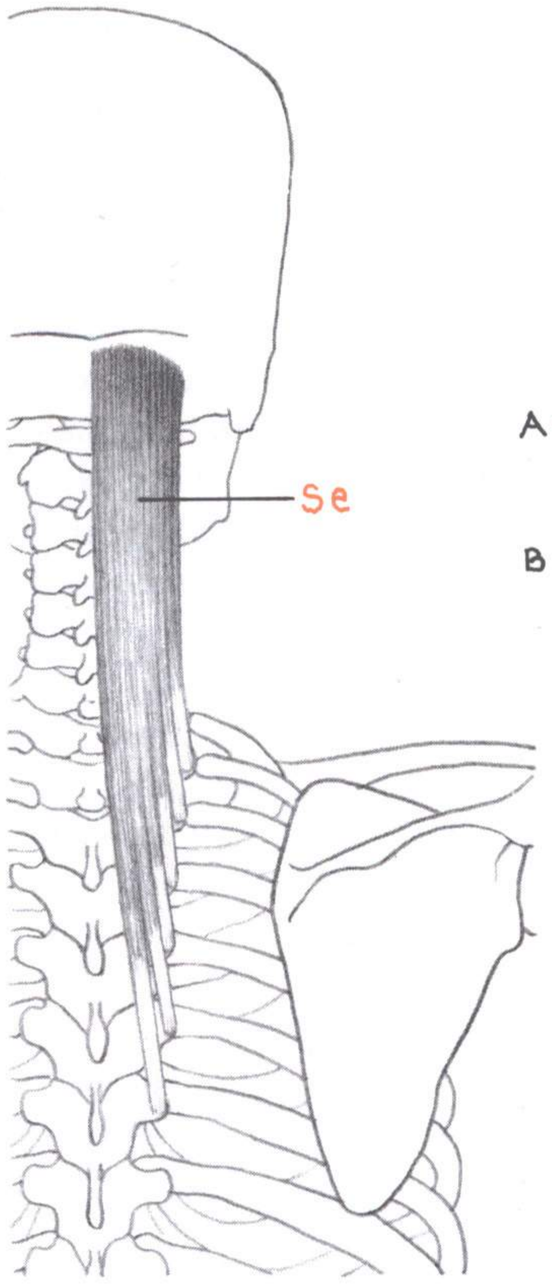
INSERTION Lower border of the anterior portion of the body of the hyoid bone, just to the side of the midline.

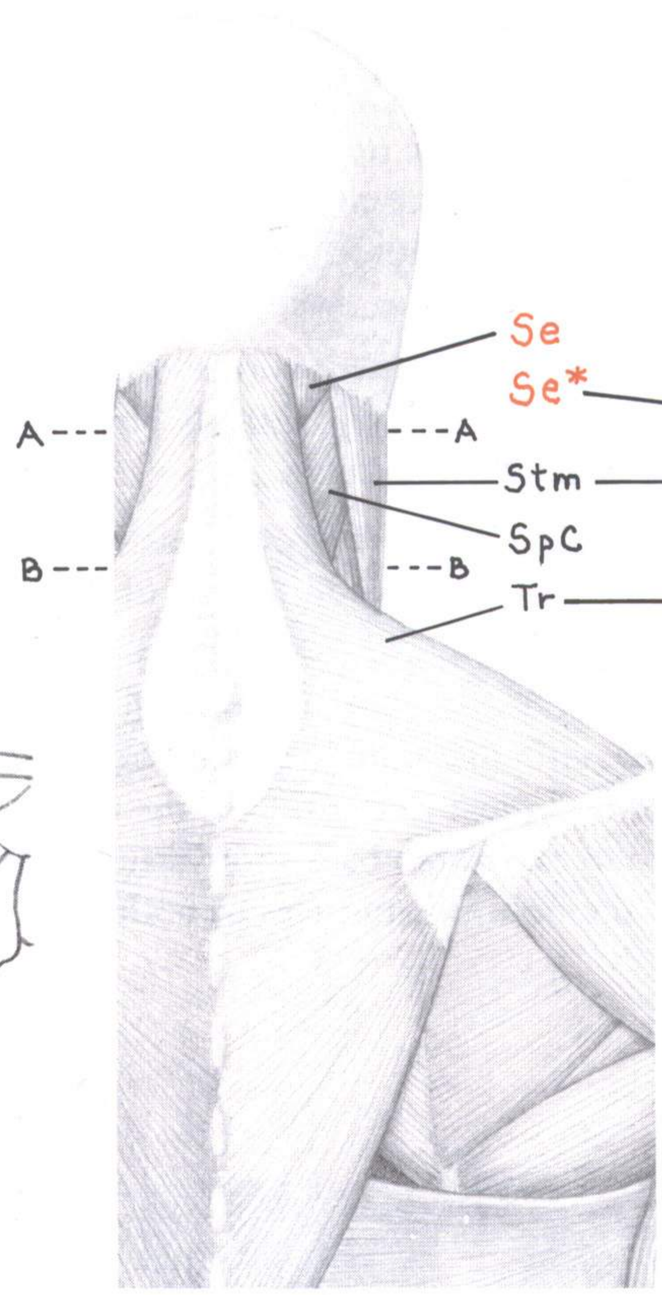
ACTION Pulls the hyoid bone down, as in swallowing; assists in flexion of the head and neck.

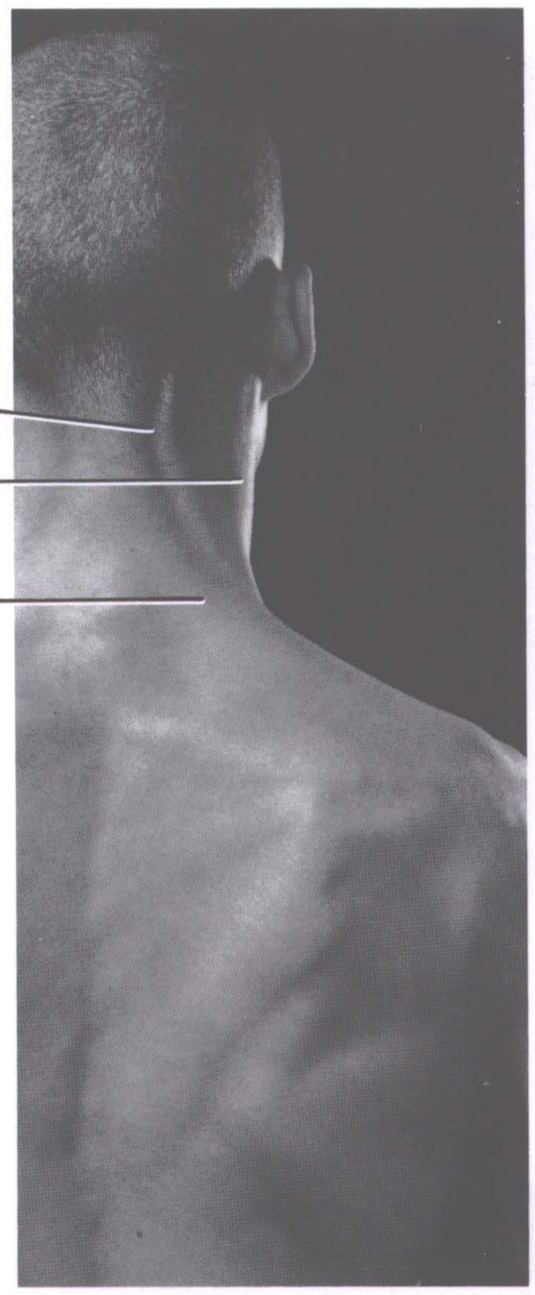
STRUCTURE The sternohyoid is a thin, narrow, straplike muscle located on the front of the neck, just to the side of the midline. Commonly separated by a short distance at the pit of the neck, the muscles of both sides converge as they ascend, but never actually touch. The space between the two muscles therefore narrows superiorly. The thyroid and cricoid cartilages and the thyroid gland are partly covered by these muscles, but are subcutaneous in the interval between them. The narrow, flat form of the sternohyoid lies on top of, but doesn't conceal, the forms of the throat (thyroid and cricoid cartilages, thyroid gland).

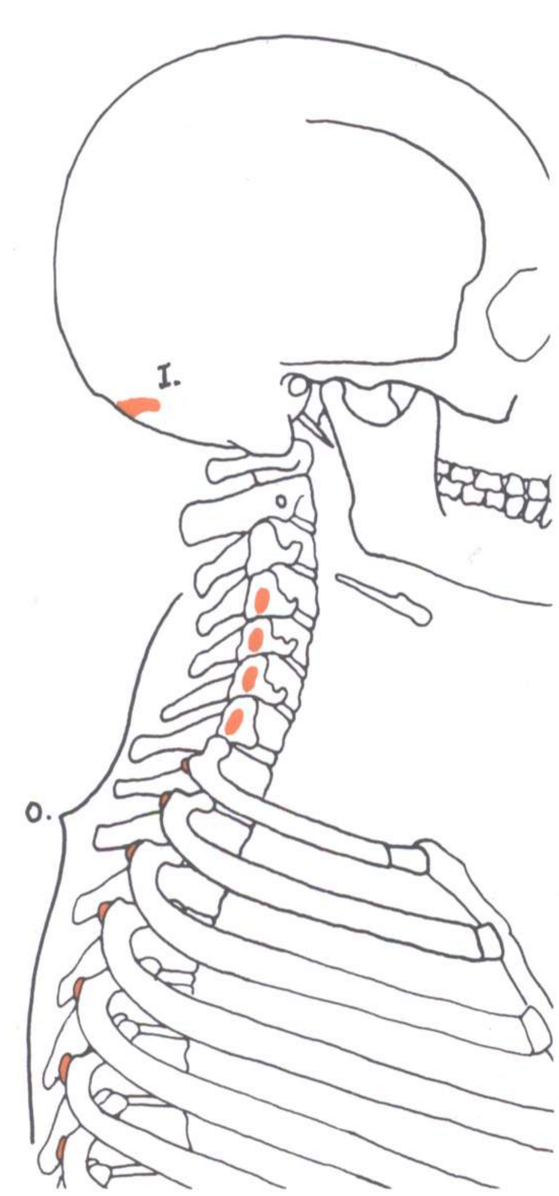
When contracting, the sternohyoids occasionally appear as two raised straps on the front of the neck, oftentimes confused with the anterior edges of the platysma. The anterior edge of the platysma is more stringy, more oblique, and located more laterally than the almost vertical sternohyoids. Also, the platysma passes *over* the sternomastoid, whereas the sternohyoid passes *under* it.

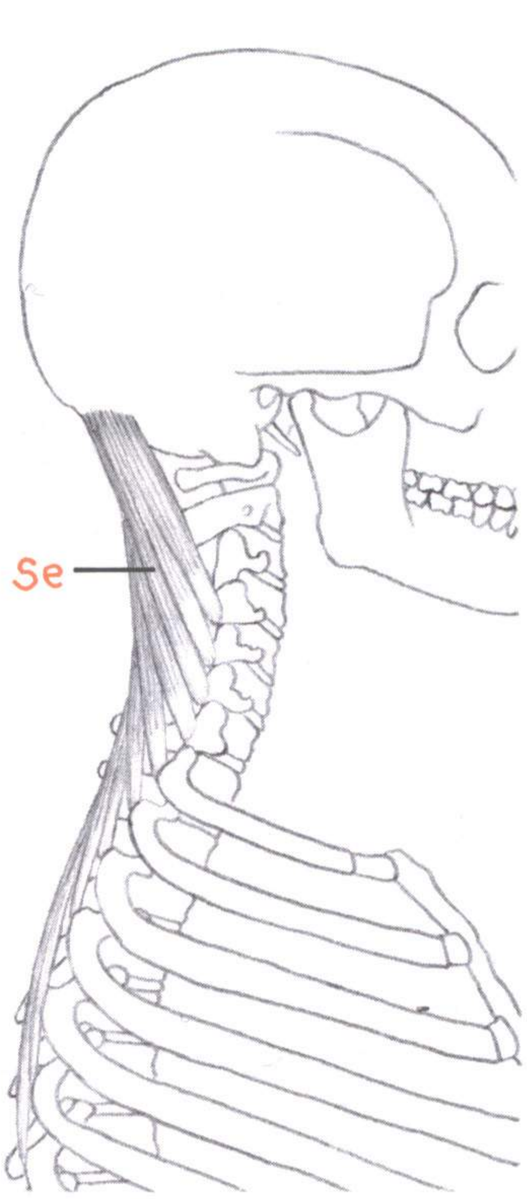


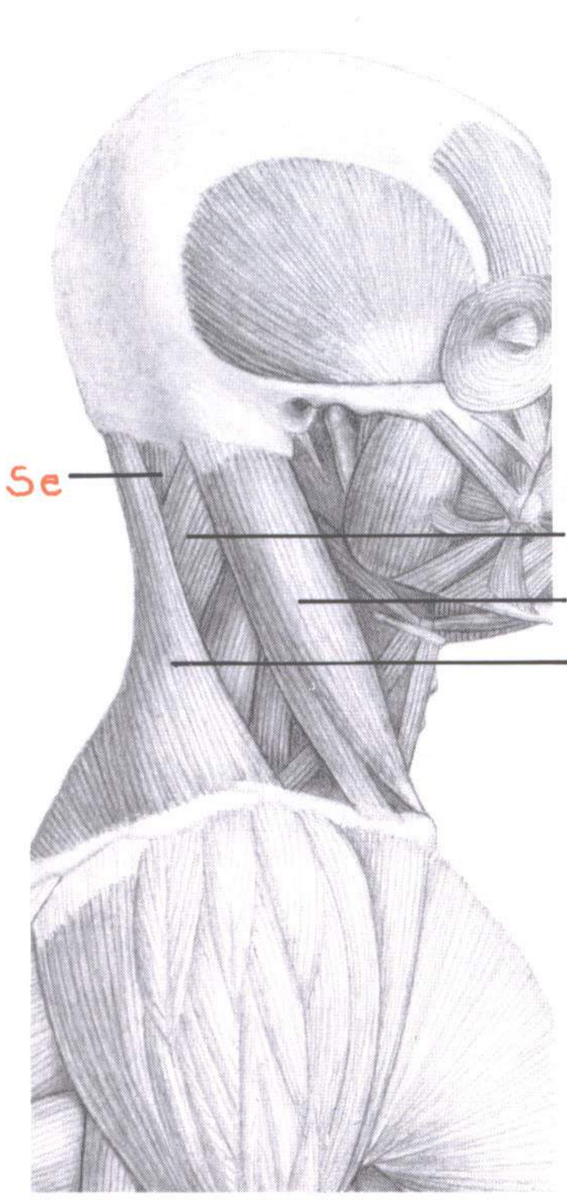


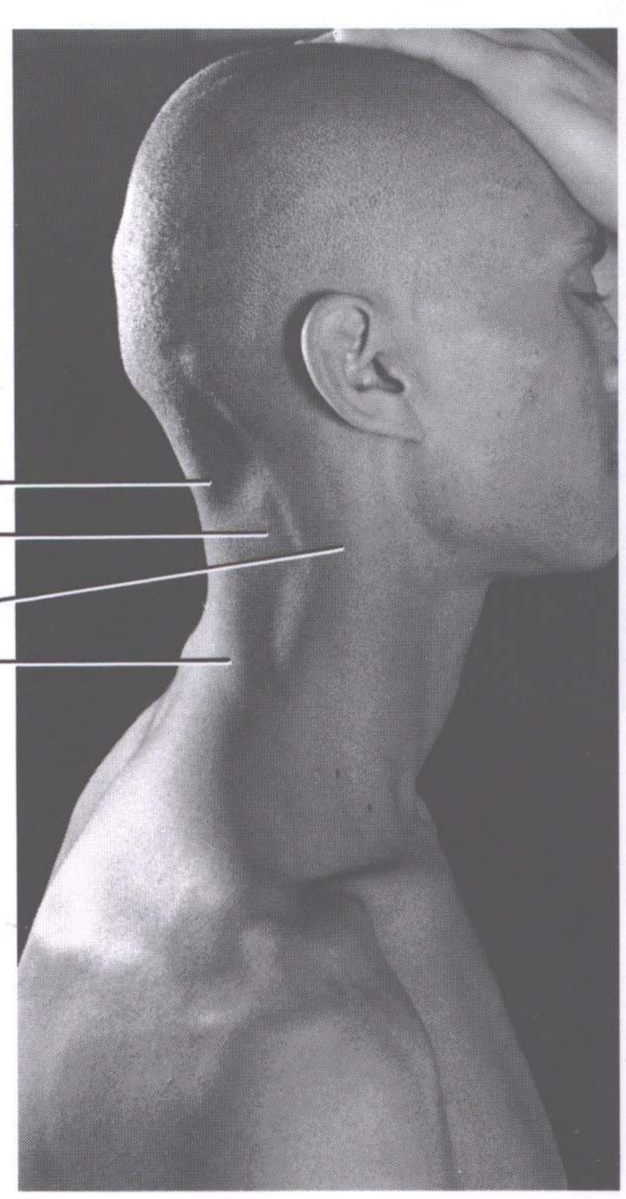




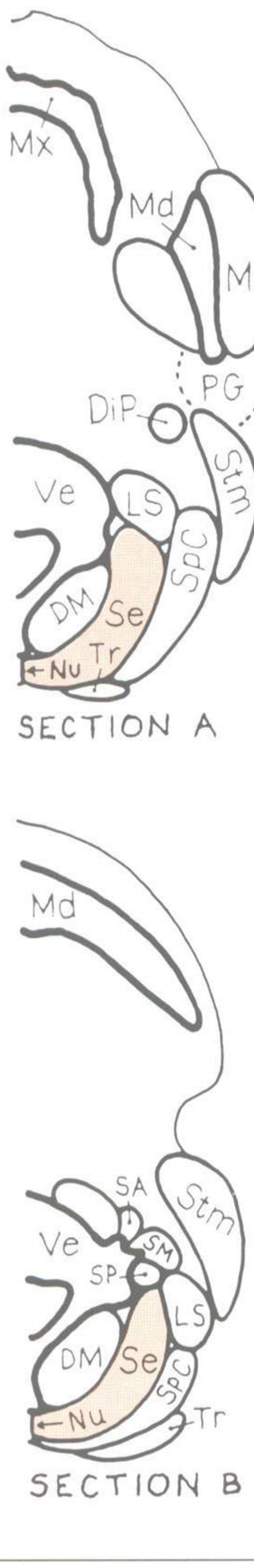








DM *Deep muscle* **Nu** *Nuchal ligament* **Se** *Semispinalis capitis* **SpC** *Splenius capitis*
Stm *Sternomastoid* **Tr** *Trapezius* * *Under trapezius*



Semispinalis Capitis (Complexus)

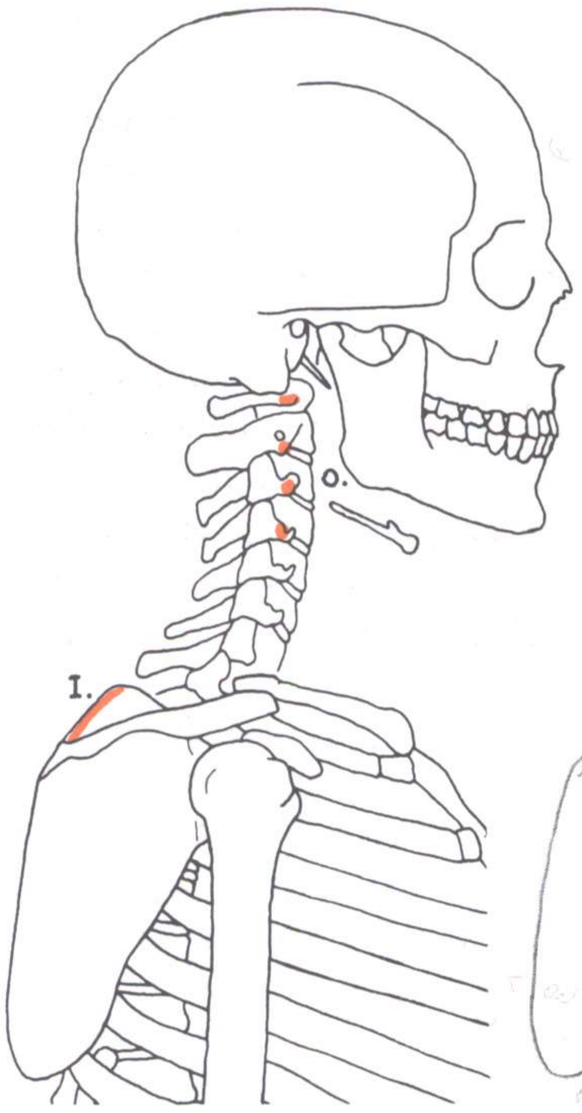
ORIGIN Tips of the transverse processes of the vertebrae from the seventh cervical down to the sixth or seventh thoracic vertebrae and from the aritcular processes of the fourth through sixth cervical vertebrae.

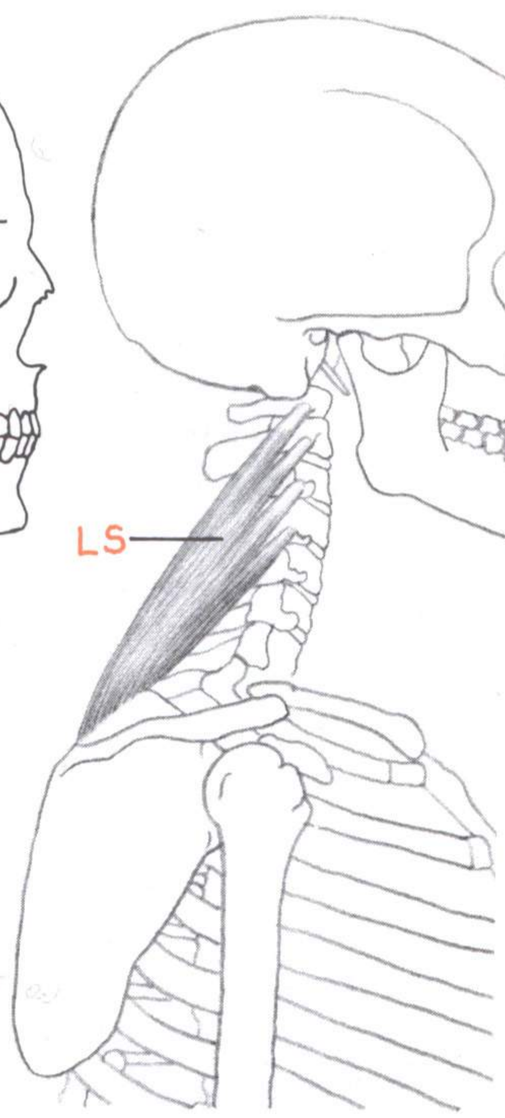
INSERTION An elongated area on the base of the skull between the superior and inferior nuchal lines of the occipital bone, just lateral to the midline.

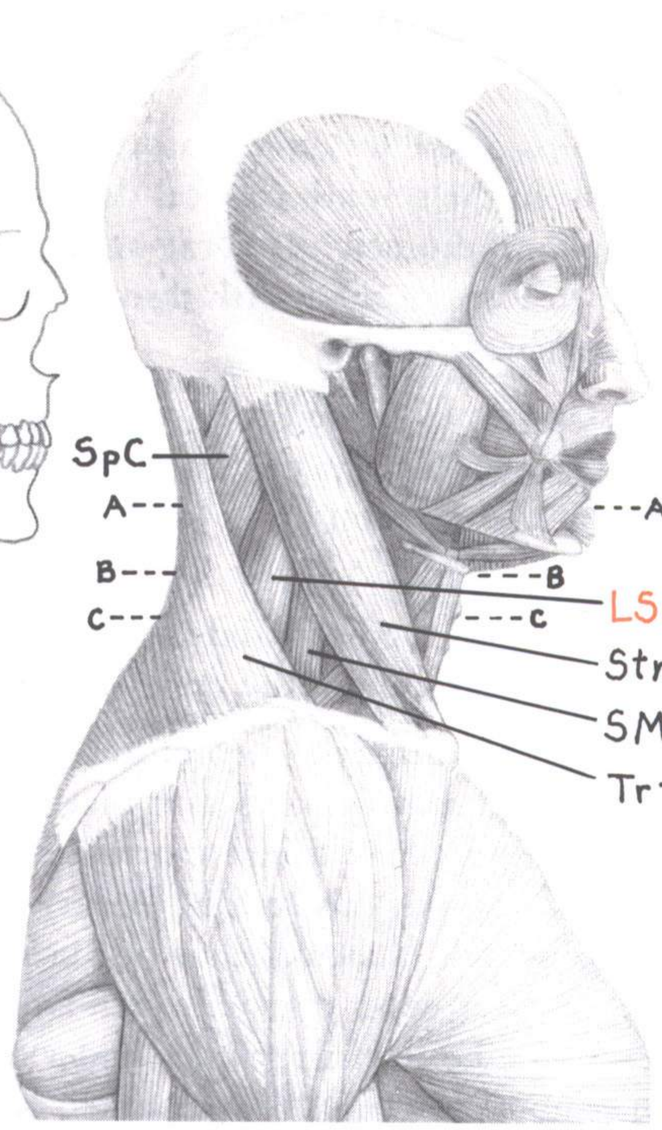
ACTION Extends the head and rotates it so that the face is directed to the opposite side.

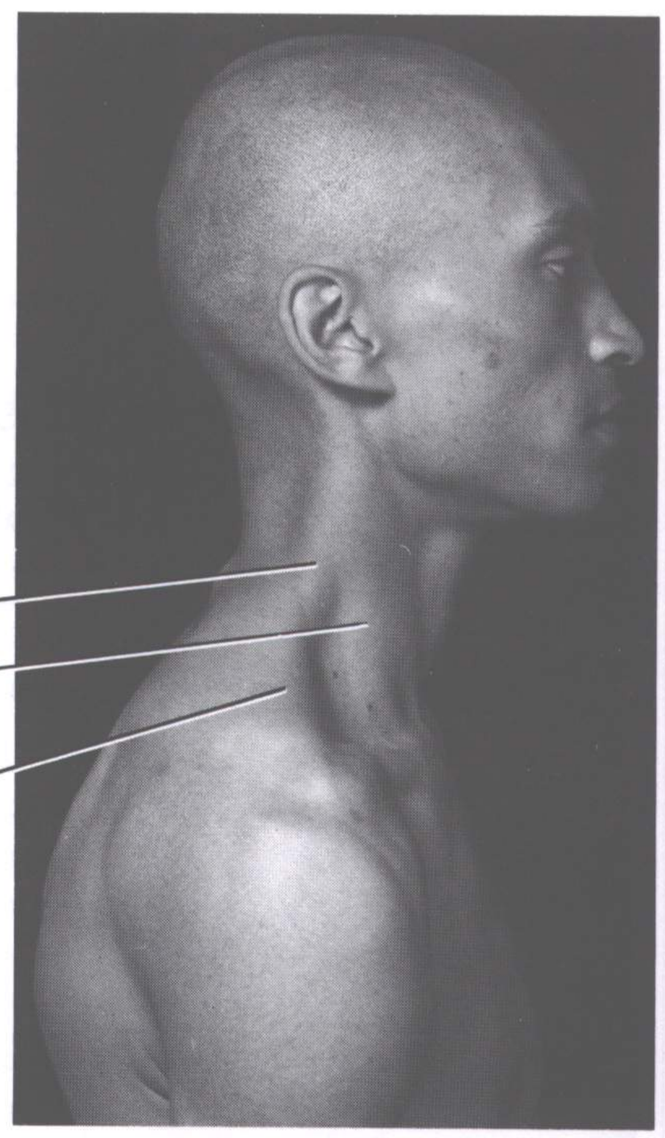
STRUCTURE Primarily a deep muscle on the back of the neck that thickens as it ascends, the semispinalis capitis makes an important contribution to the form of this region. (A very small part of it is actually subcutaneous just below the skull, but is is never distinctly seen and is usually covered by the hair.) It lies under the thin uppermost portion of the trapezius, and *both* muscles create the muscular column on the back of the neck immediately to the side of the nuchal ligament. These muscles of both sides of the body are therefore partly responsible for creating the two thick cords that characteristically appear on the back of the neck (except when the head is fully flexed). The furrow on the midline between these two columns (the posterior free edge of the nuchal ligament) deepens as it approaches the skull, ending superiorly at the external occipital protuberance (the cranial attachment of the nuchal ligament). A depression may form between the upper end of the semispinalis capitis and the sternocleidomastoid, in which the subcutaneous portion of the splenius capitis lies.

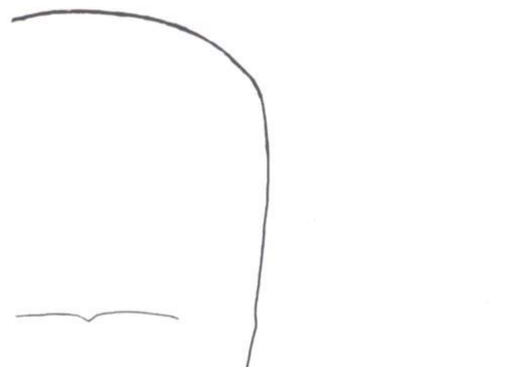
Basically vertical, the thick, somewhat flattened belly of the semispinalis capitis wraps around the deeper structures of the neck, best seen in cross section. The semispinalis capitis is part of the transversospinalis muscle group—the deepest muscle group of the back—which includes the multifidus. The medial portion of the semispinalis capitis, which tends to merge with the spinalis capitis, is called the **biventer cervicis.**

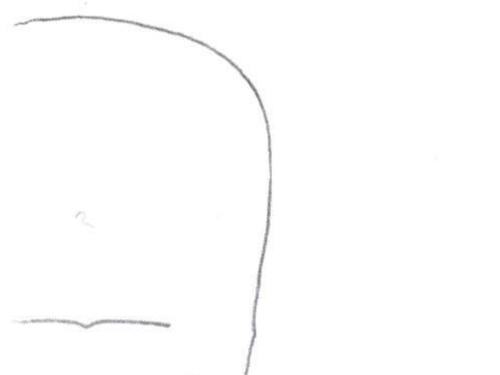


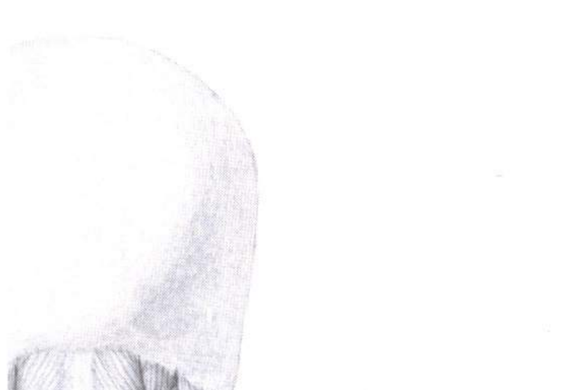




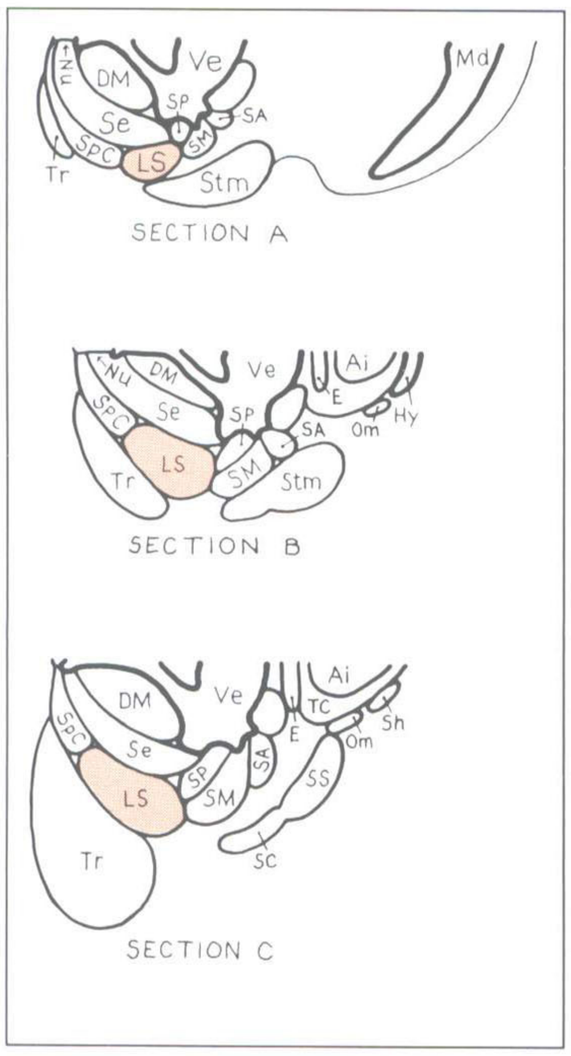


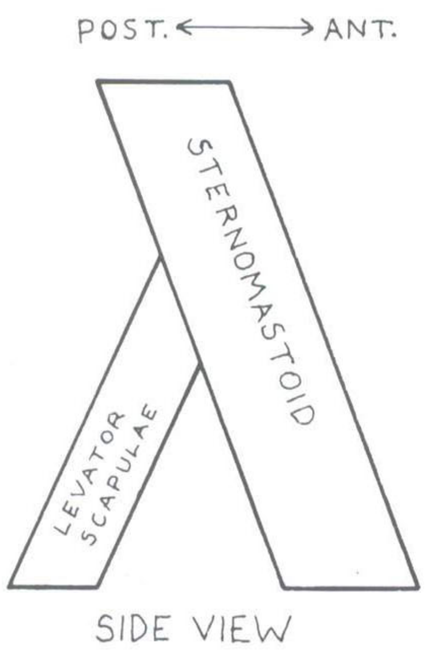






LS *Levator scapulae* **Se** *Semispinalis capitis* **SM** *Scalenus medius* **SpC** *Splenius capitis*
Stm *Sternomastoid* **Tr** *Trapezius*





Levator Scapulae

ORIGIN Transverse processes of the first four cervical vertebrae.

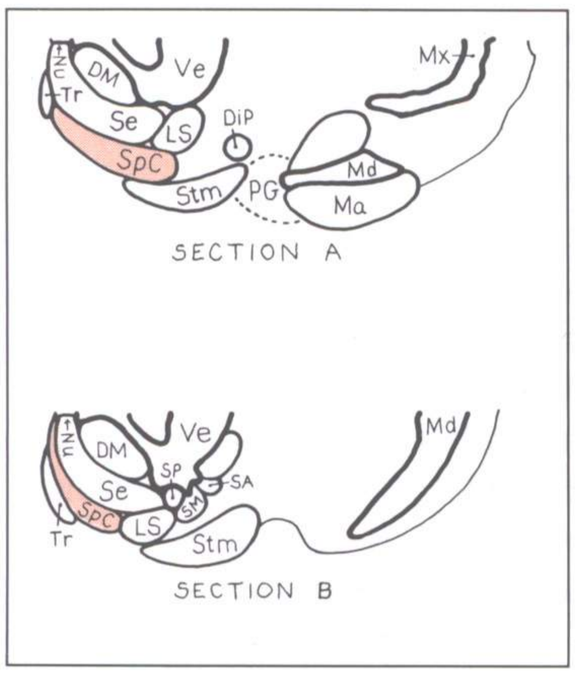
INSERTION Upper portion of the vertebral border of the scapula, between the superior angle and the base of the spine of the scapula.

ACTION Raises the scapula while pulling it slightly medially. It assists in rotation of the scapula by raising the vertebral border, which produces downward rotation of the acromion. When the shoulder is fixed, it will bend the neck laterally.

STRUCTURE Beginning deep in the side of the neck just below the skull, and ending deep in the back at the top of the shoulder, the levator scapulae is superficial only in its middle third, in the space between the sternomastoid and trapezius on the side of the neck. When the muscles located in this interval are defined, the levator scapulae is usually the most prominent. In side view, the axis of its narrow, cylindrical, subcutaneous form is oriented on a line directed from the earlobe to the deep superior angle of the scapula. The levator scapulae is located anterior to the splenius capitis, but whereas the splnius capitis is directed downward and *medially* toward the midline of the back, the levator scapulae is directed downward and *laterally* toward the top of the scapula. The levator scapulae is the more prominent of the two, but they may also blend together.

The levator scapulae is located at the front edge of the **muscle mass of the back of the neck.** This mass is made up of the trapezius, semispinalis capitis, splenius capitis, and levator scapulae; it can be seen separating from the sternomastoid and the front half of the neck when the head is fully rotated to one side. The levator scapulae and scalenus medius are responsible for the width at the side of the base of the neck.

The levator scapulae is often difficult to see, regardless of muscular development. It is most likely to be seen in individuals with very little fat and in the elderly, especially when the arms are carrying weight and the shoulder is slightly raised, or when the neck is bent laterally against resistance. When seen, the combined forms of the levator scapulae and sternomastoid create an inverted V, with the upper end of the former passing deep to the latter.



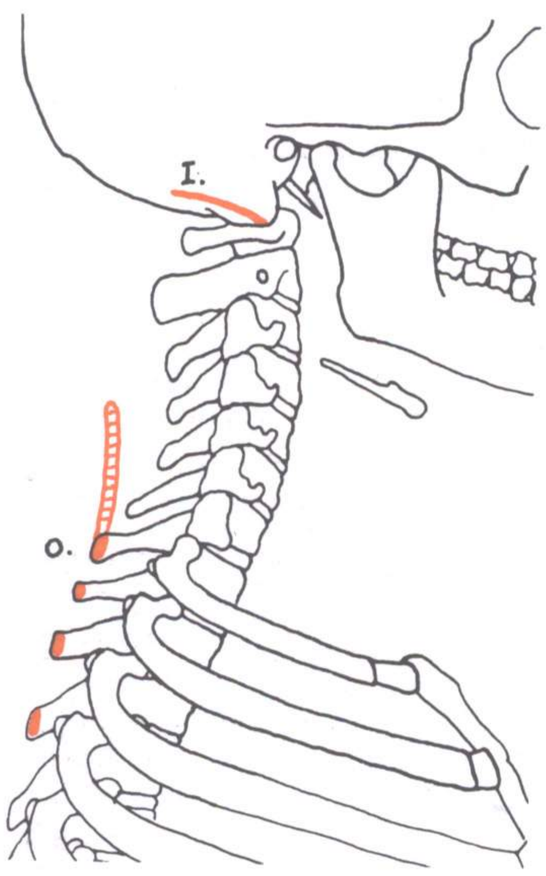
Splenius Capitis

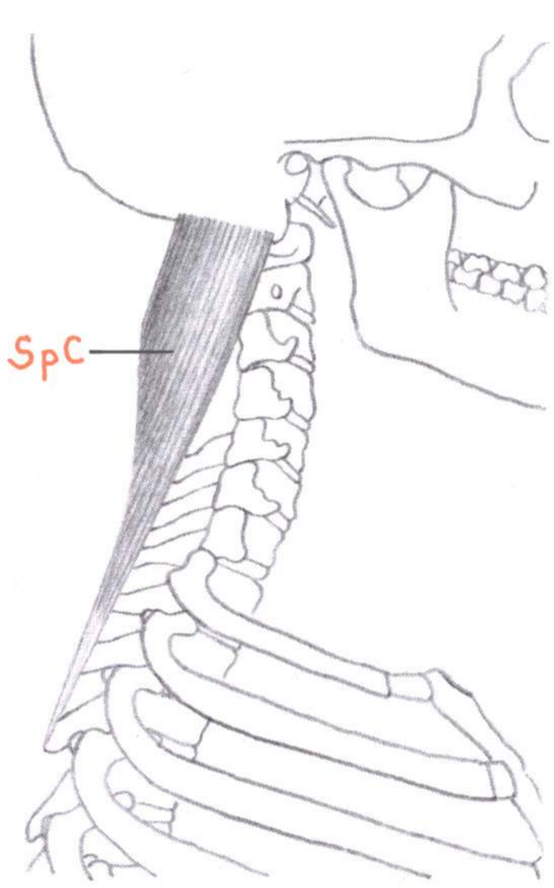
ORIGIN The lower half of the posterior free edge of the nuchal ligament and the spinous processes of the seventh cervical and first three or four thoracic vertebrae.

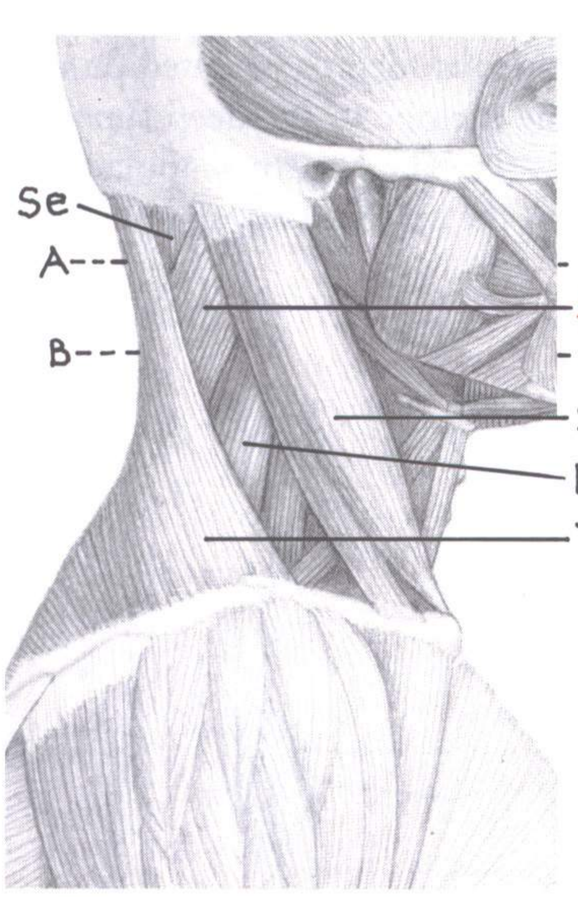
INSERTION A line at the side of the base of the skull, just deep to the insertion of the sternomastoid, from the tip of the mastoid process extending back about two inches.

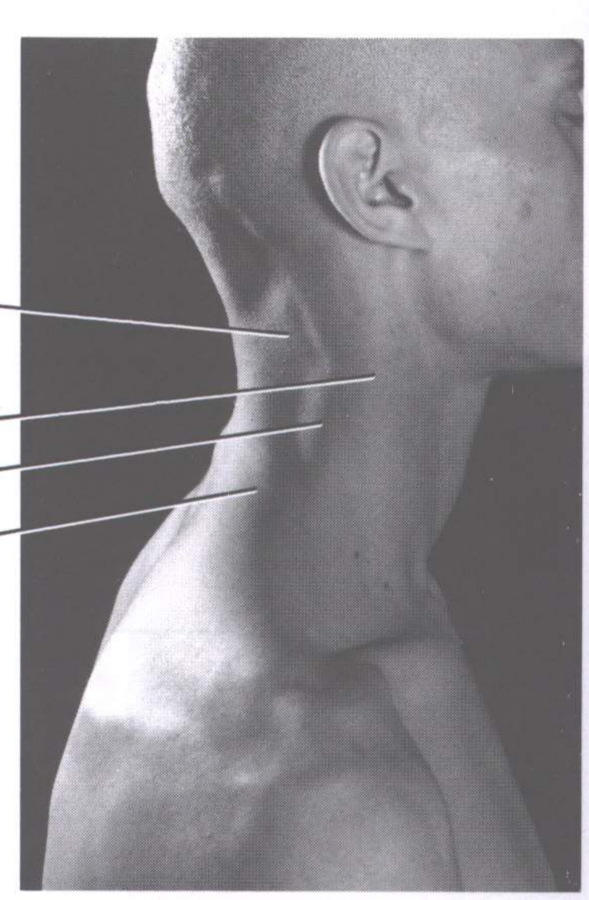
ACTION Rotates the head, turning it toward the same side as the active muscle. The muscles of both sides contracting together extend the head.

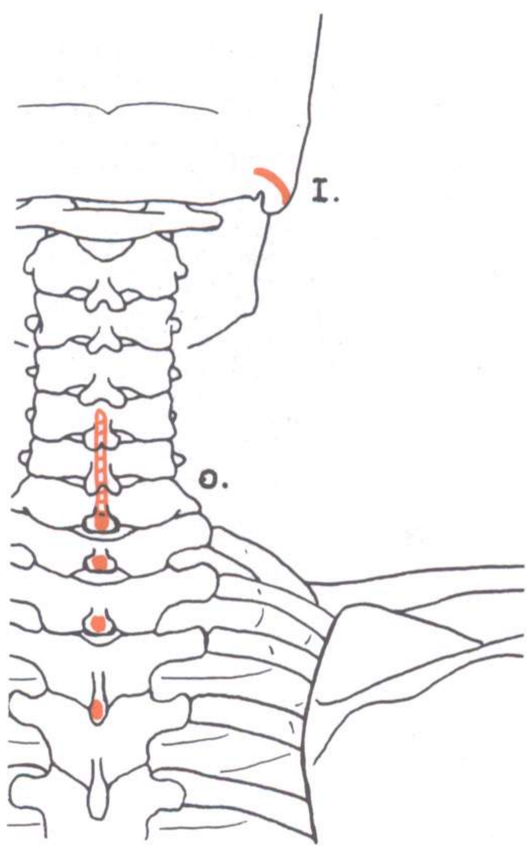
STRUCTURE The splenius capitis is a broad, sheetlike, inconspicuous muscle located on the back of the neck. Only a small area of its superior portion is superficial. When seen, its superficial portion is directed *to the mastoid process.* The front edge of the muscle, which lies at the back edge of the form of the levator scapulae, can be traced along a line from the tip of the mastoid process downward to the back of the base of the neck. The form of the levator scapulae is stronger and more pronounced than that of the splenius capitis.

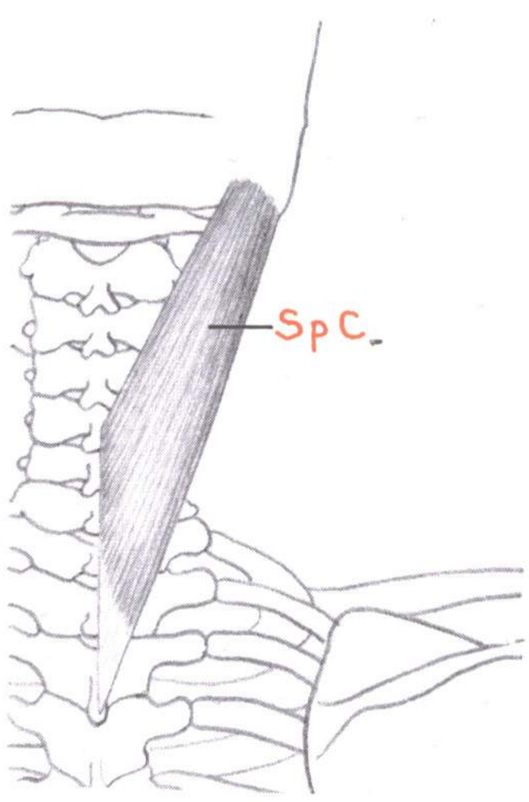


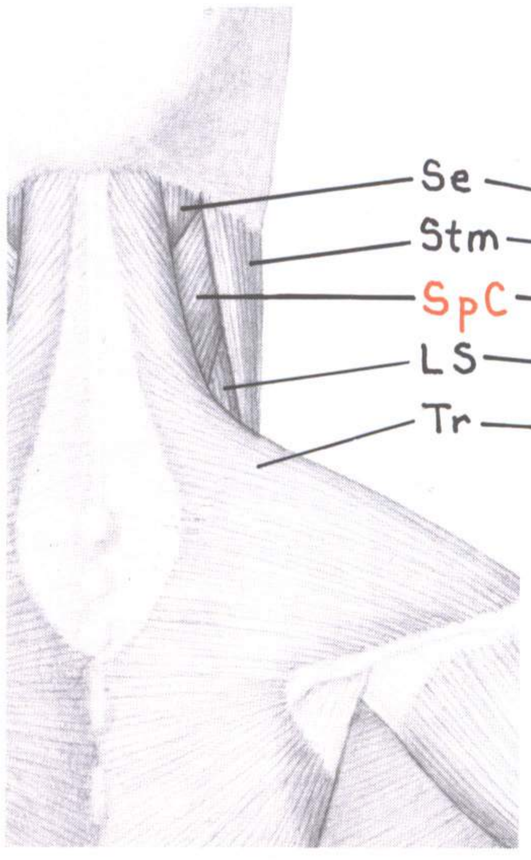


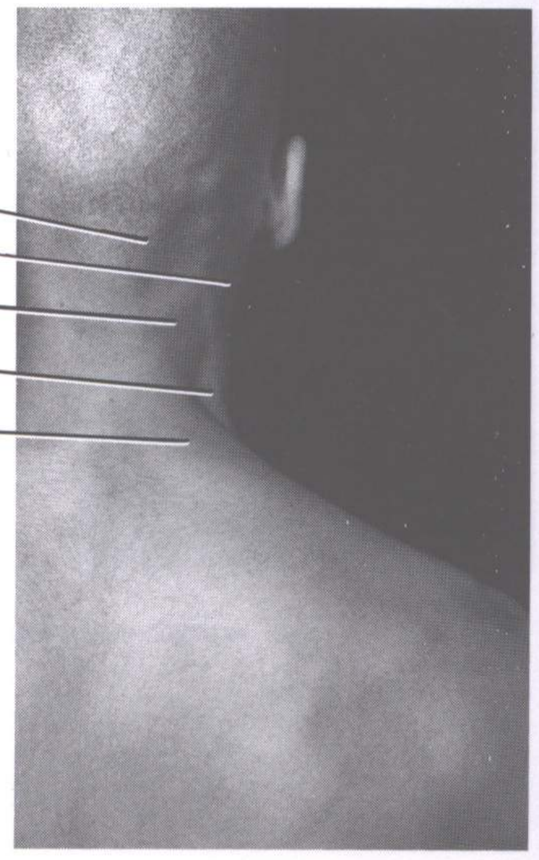




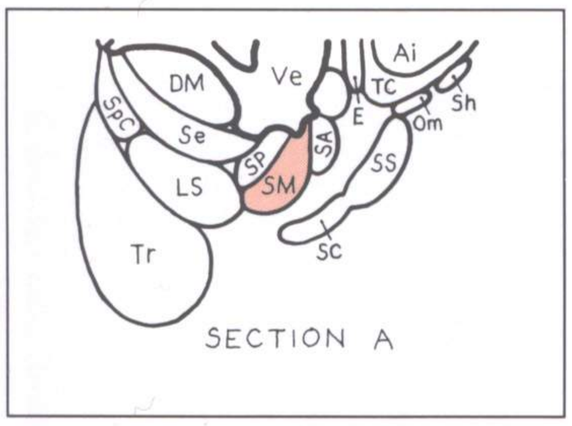


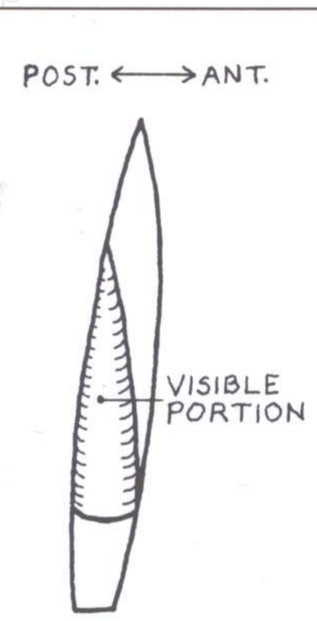






LS *Levator scapulae* **Nu** *Nuchal ligament* **Om** *Omohyoid* **SA** *Scalenus anterior*
SC *Sternomastoid—clavicular head* **Se** *Semispinalis capitis* **SM** *Scalenus medius* **SP** *Scalenus posterior*





Scalenus Medius

ORIGIN Transverse processes of the second through seventh cervical vertebrae (and occasionally from the atlas).

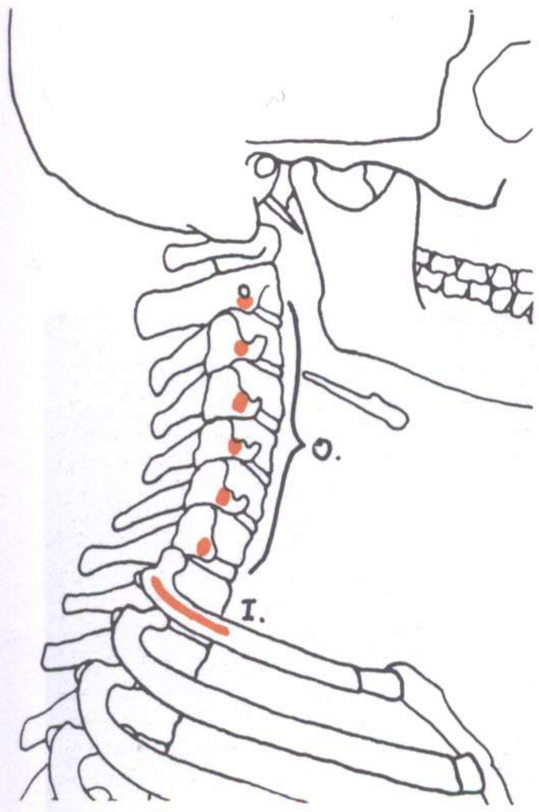
INSERTION Upper surface of the first rib, from its midpoint back to the tubercle.

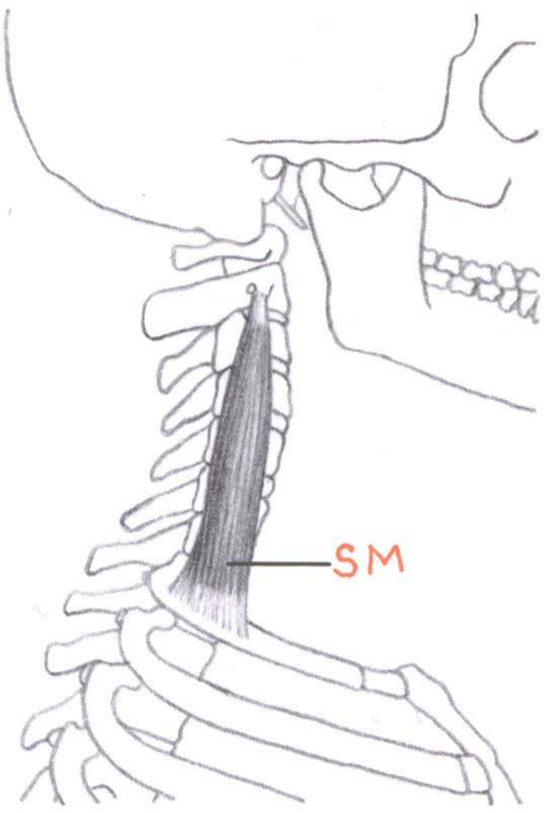
ACTION Bends the neck laterally; lifts the first rib during forced inspiration.

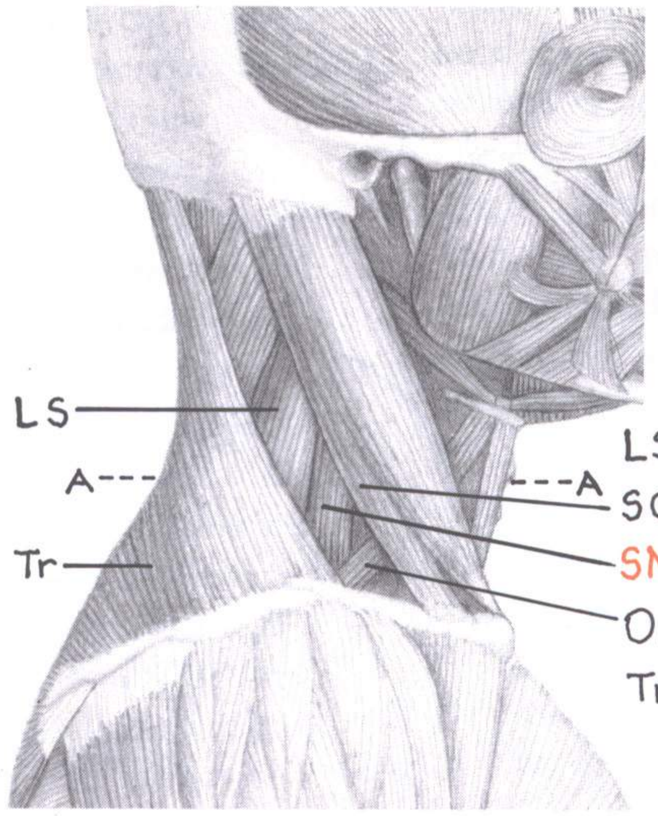
STRUCTURE Largest of the scalene muscles, the **scalenus medius** shows up on the middle of the lower half of the side of the neck, but not very prominently. It adds thickness to the bottom of the side of the neck where the neck flares, and is usually covered by some of the supraclavicular fat. The muscle appears as a short, vertical, conical form, pointed superiorly, between the inverted V of the forms of the sternomastoid and levator scapulae. The scalenus medius may appear during forced inspiration.

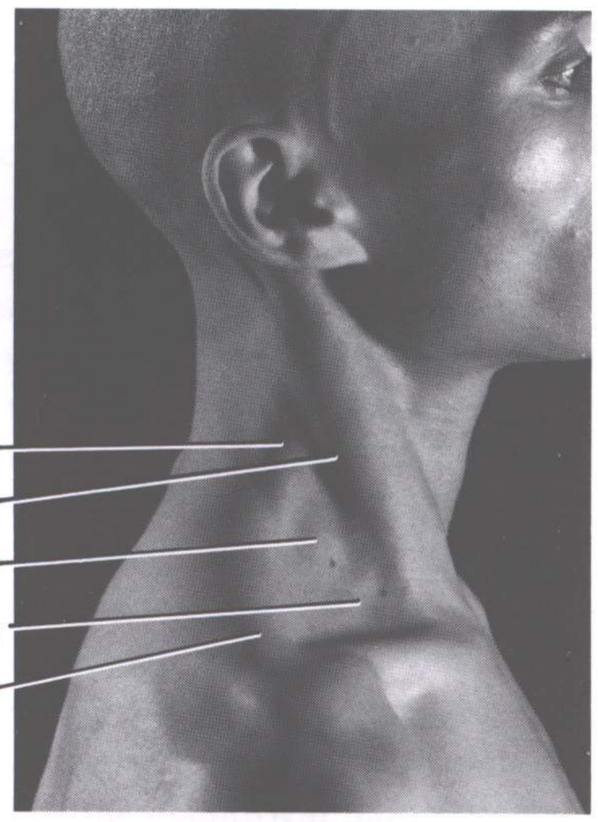
The **scalenus posterior,** arising from the transverse processes of the fourth through sixth cervical vertebrae, and inserting onto the top surface of the second rib posterior to its midpoint, is never distinct, but blends into the back of the form of the scalenus medius. The **scalenus anterior** is too deep to affect surface form.

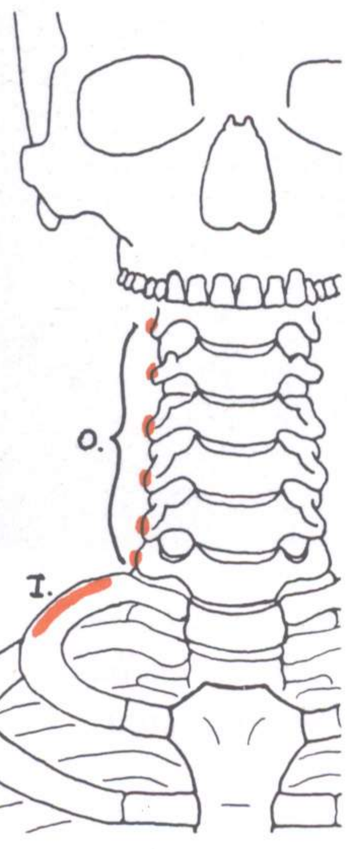
At times, some of the nerves of the **brachial plexus** can be seen as a raised cordlike ridge passing down along the anterior edge of the form of the scalenus medius.

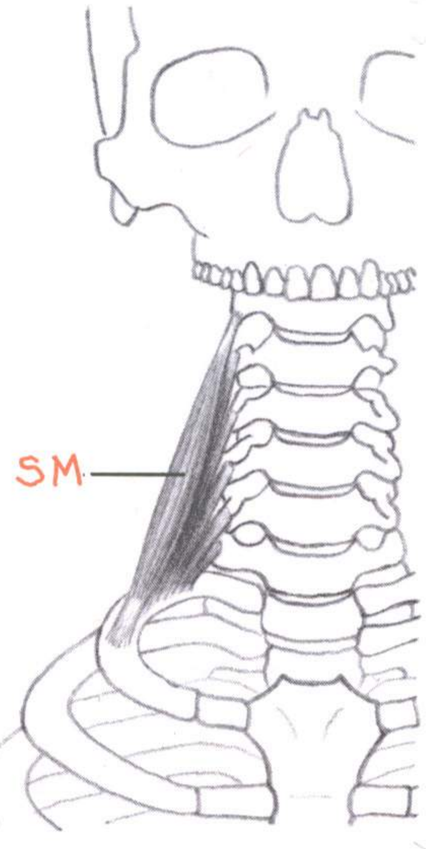


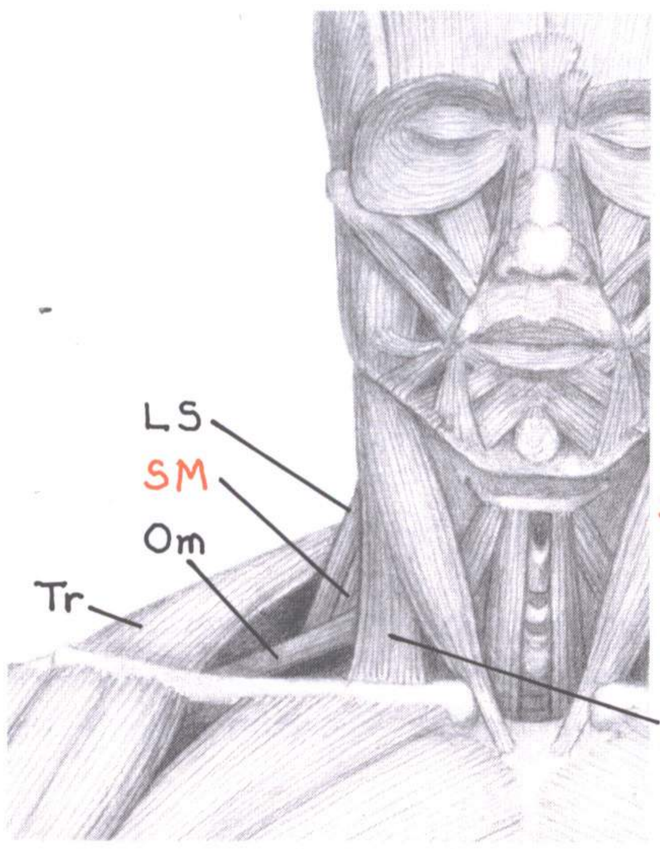


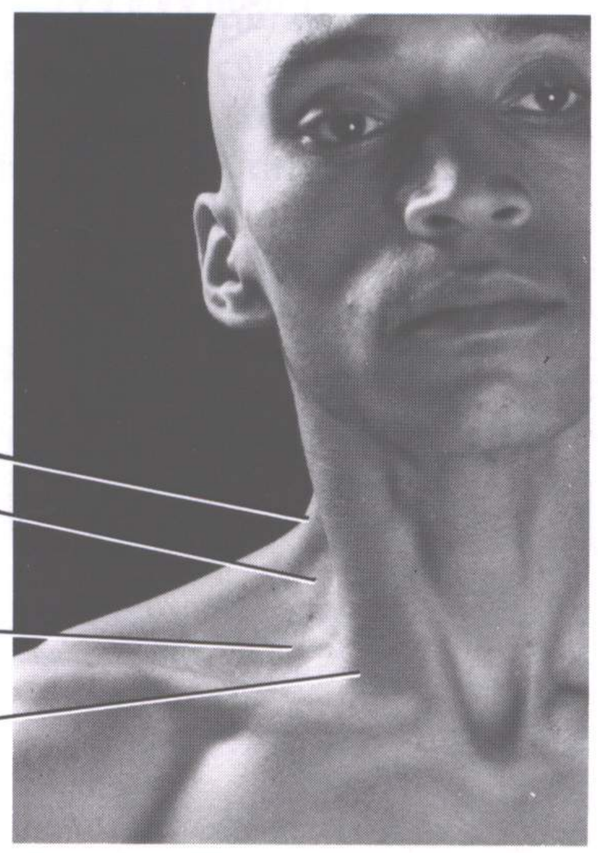




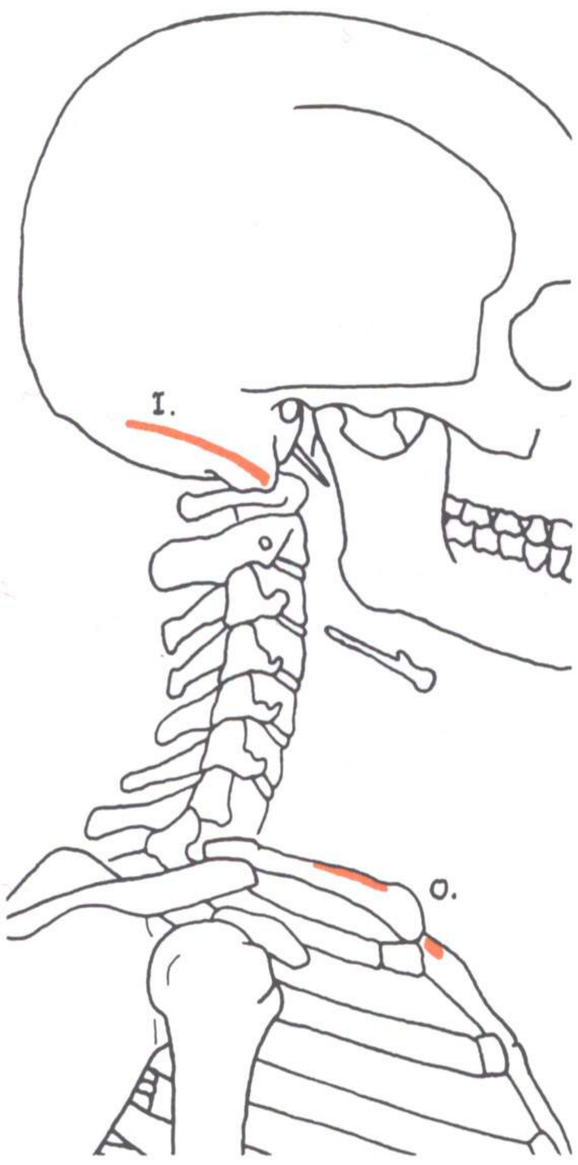


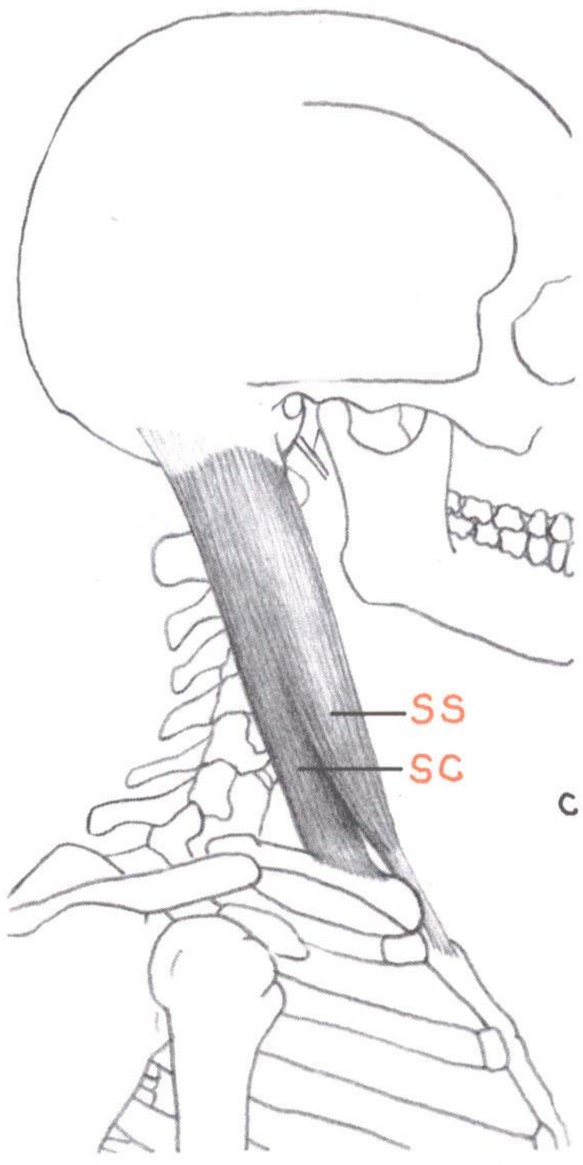


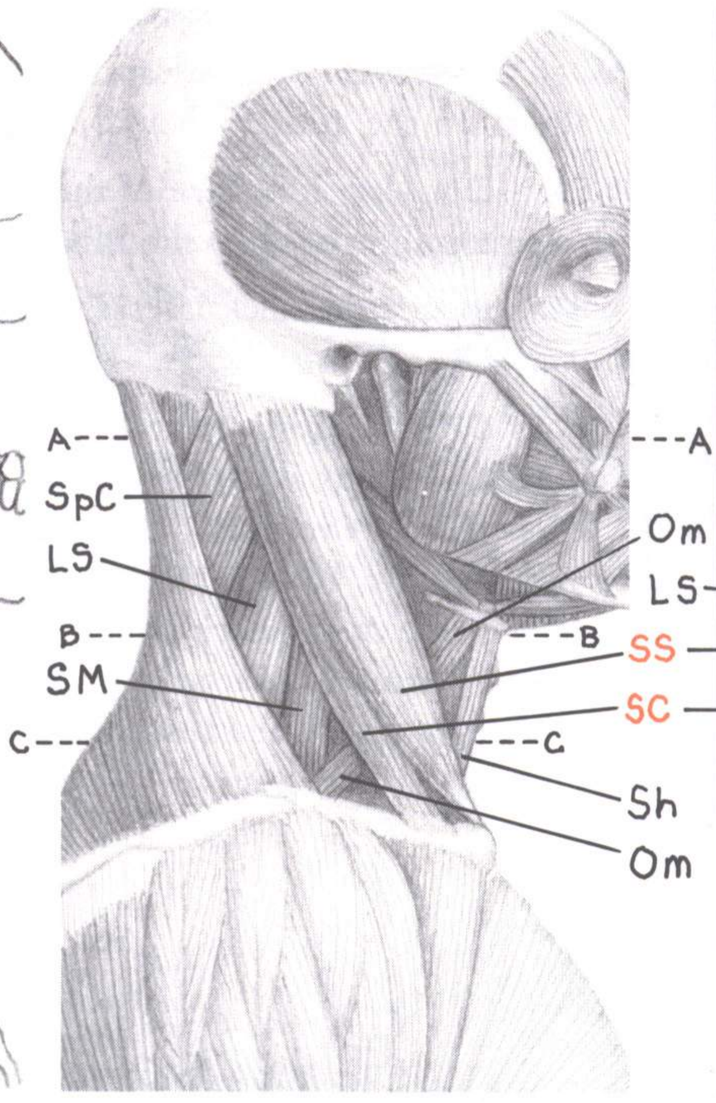


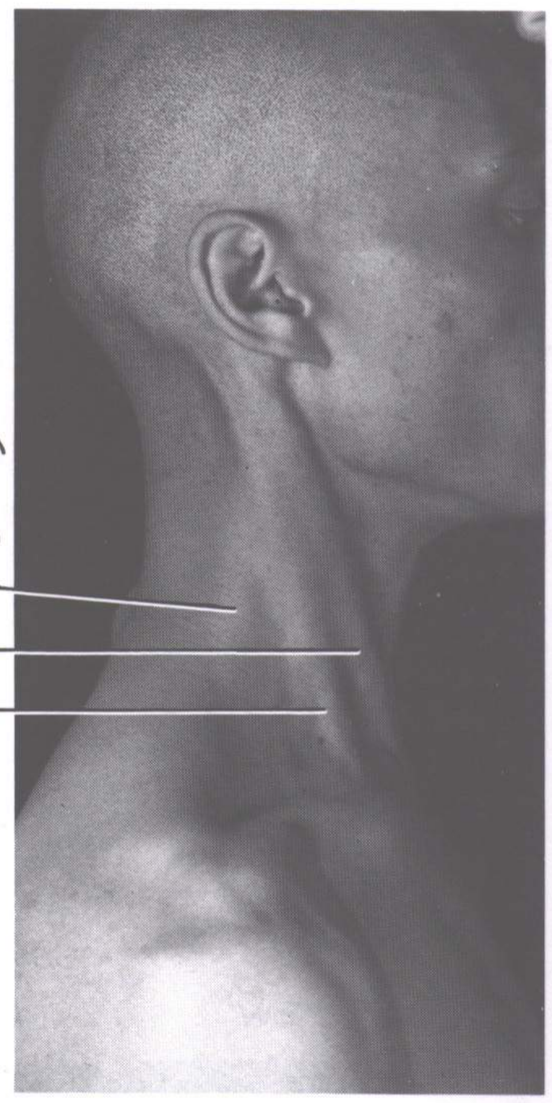


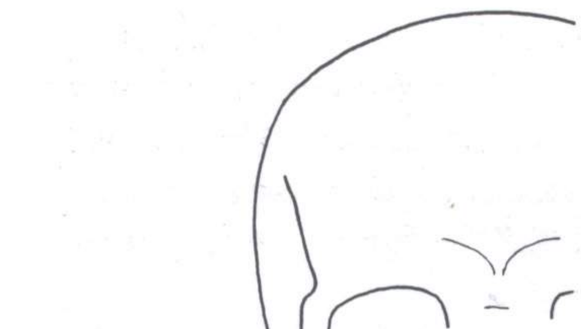
SpC *Splenius capitis* **Stm** *Sternomastoid* **Tr** *Trapezius* **Ve** *Vertebra*

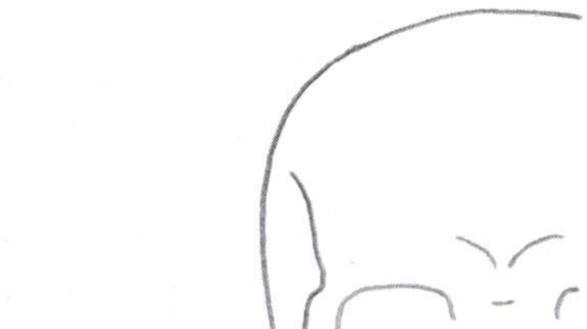


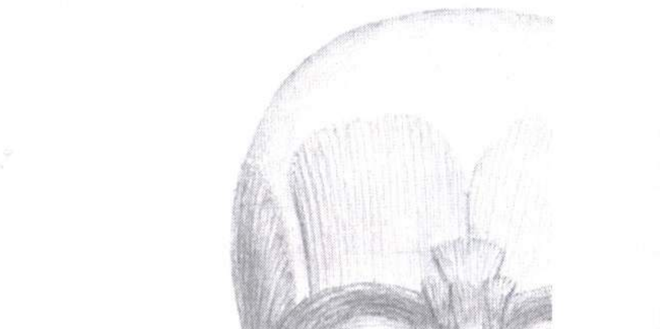


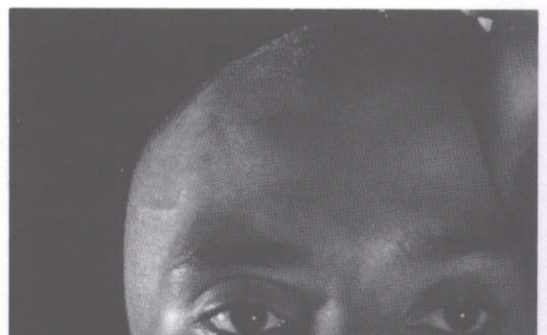




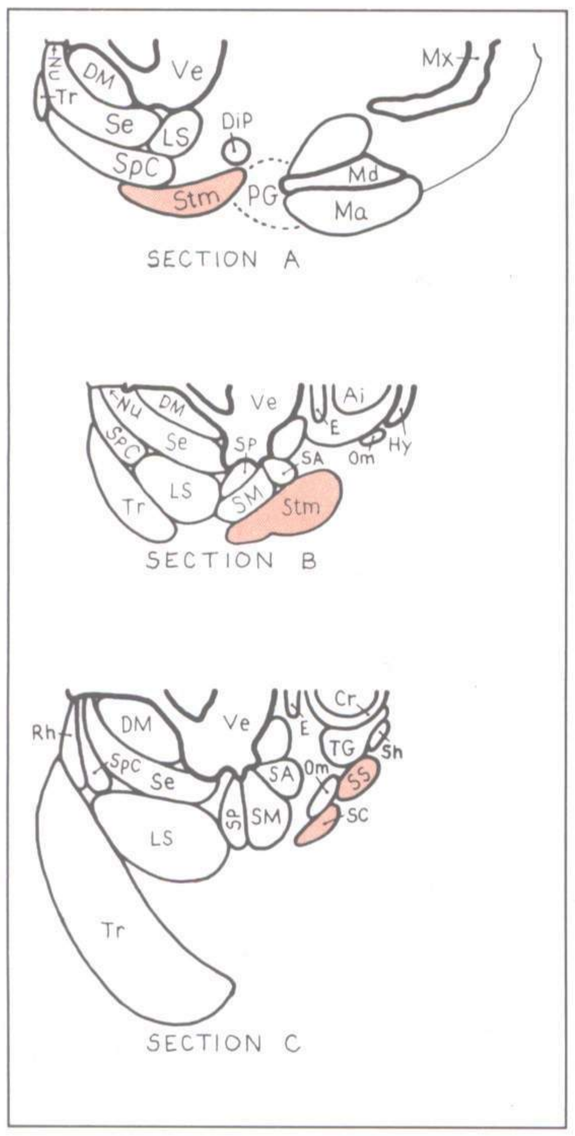


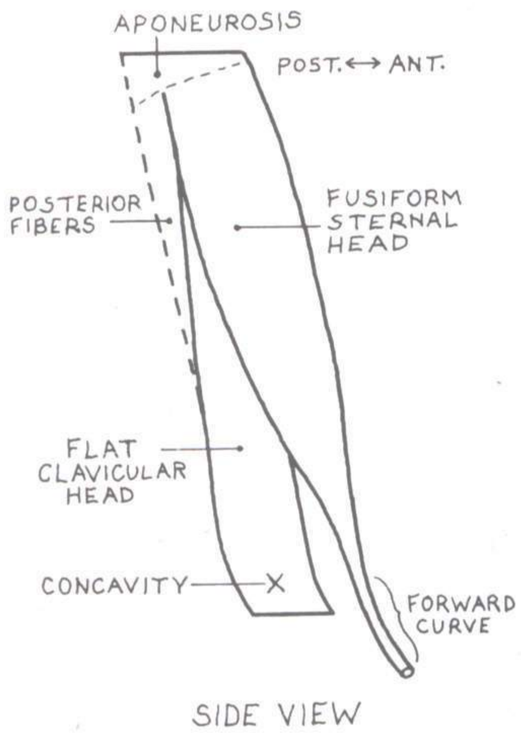






LS *Levator scapulae* **Mn** *Manubrium* **MP** *Mastoid process* **Om** *Omohyoid* **PG** *Parotid gland*
SA *Scalenus anterior* **SC** *Sternomastoid—clavicular head* **Sh** *Sternohyoid* **SM** *Scalenus medius*
SpC *Splenius capitis* **SS** *Sternomastoid—sternal head* **Stm** *Sternomastoid* **TG** *Thyroid gland*





Sternocleidomastoid (Sternomastoid)

ORIGIN *Sternal head:* Upper part of the anterior surface of the manubrium of the sternum, near the midline. *Clavicular head:* Upper surface of the medial third of the clavicle, excluding the medial expansion of the clavicle. The area of origin extends downward onto the front surface of the clavicle.

INSERTION A line along the tip, anterior border, and lateral surface of the mastoid process of the skull (behind the ear), continued around posteriorly into the lateral part of the superior nuchal line of the occipital bone at the base of the skull.

ACTION Both sides together flex the head and neck forward. Acting alone, it will bend the head and neck laterally and rotate the face toward the opposite side.

STRUCTURE The sternocleidomastoid (sternomastoid) is a wide, basically straplike muscle, thickest at its center, that spirals obliquely down the side of the cylindrical form of the neck. It passes from behind the ear toward the pit of the neck, and stands out prominently in action. The single belly consists of two heads, which when tensed can be seen separating into the thicker, more prominent, *fusiform* sternal head and the wider, *flattened,* straplike clavicular ("cleido") head. The sternal head can be seen from origin to insertion; the clavicular head is usually visible on the lower half of the neck only (the upper half of the clavicular head blends into the dominant sternal head).

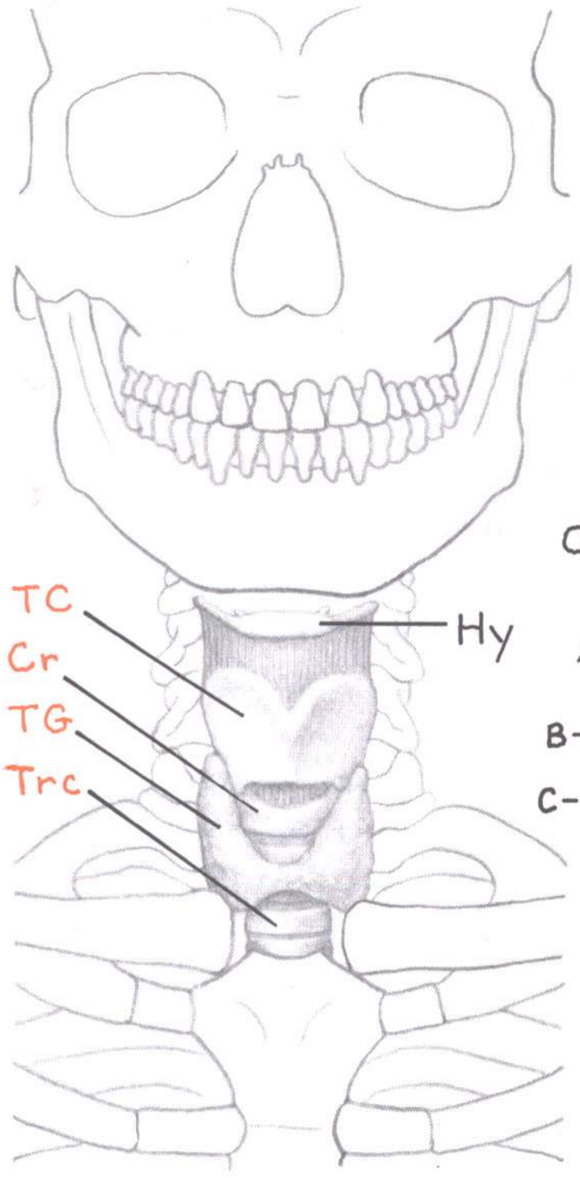
The superior end of the muscle (the single belly made up of its two fused heads) becomes aponeurotic, especially posteriorly, before it inserts into the skull. Inferiorly, the sternal and clavicular heads are usually separated by a small triangular interval just above the medial expansion of the clavicle.

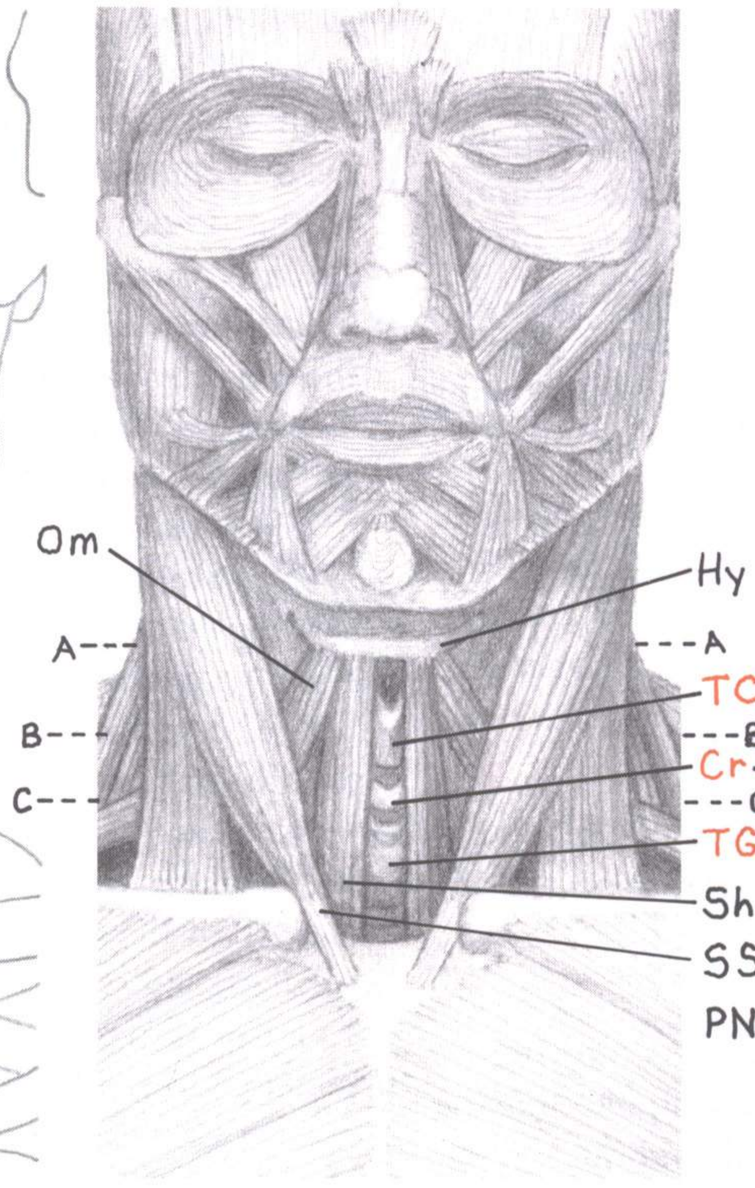
The **sternal head** tapers inferiorly into a strong tendon that appears round, conspicuous, and cordlike on the surface as it passes *medial* to the expanded medial end of the clavicle (not in front of it). When the head (skull) faces forward, the inferior end of the sternal head curves slightly forward toward the sternum. When the head is completely rotated to one side, the sternal head becomes vertical and almost cylindrical in cross section, and forms the anterior profile of the neck. Along with the upper edge of the manubrium of the sternum, the tendons of the sternal heads of both sides of the body (not the medial ends of the clavicles) define the pit of the neck.

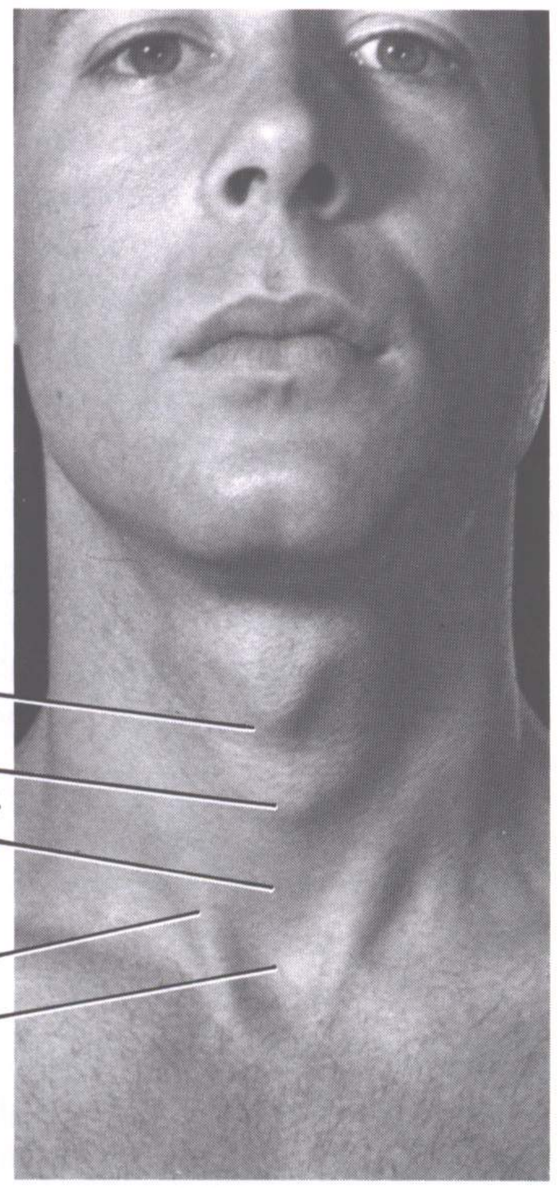
The inferior end of the **clavicular head** usually dips downward slightly before heading forward to the clavicle (creating a gentle concavity). The widened form of the clavicular head usually ends inferiorly at the top of the clavicle, leaving the form of the front of the clavicle visible. This head continues onward to the front surface of the clavicle, but only via its nonvisible flattened tendon. The upper half of the clavicular head normally becomes partially or completely covered by the sternal head as the two heads blend together.

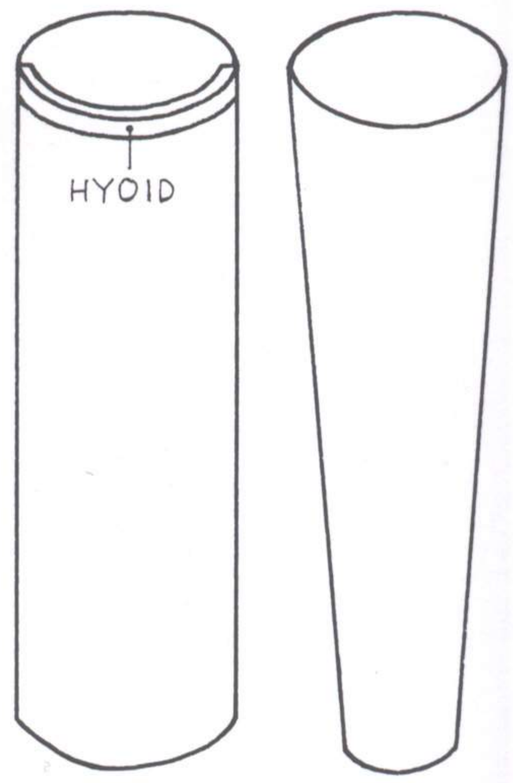
The most posterior fibers of the clavicular head are usually inconspicuous, but when extremely tensed (head bent laterally against resistance), they become visible along their entire length, passing from the skull to the clavicle. They then appear as one or more independent narrow bundles descending from the aponeurosis at the very posterior end of the line of attachment on the skull to the lateral end of the line of attachment on the clavicle. The interval between the posterior edge of the sternocleidomastoid and the anterior edge of the trapezius then appears narrower.

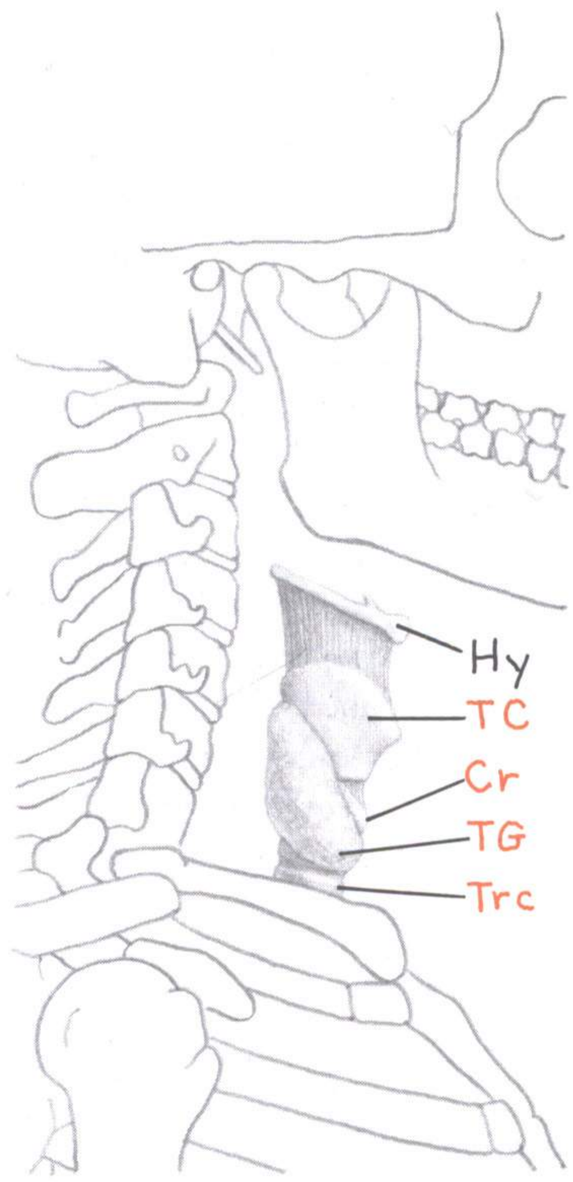
The sternocleidomastoids form the sides of the neck, converging as they advance anteriorly in their descent. When relaxed, the sternomastoids contribute to the cylindrical nature of the neck; when tensed, they become reliefs that rise up from the surface of the cylinder. The neck widens when it is extended, becoming widest two-thirds of the way down the sternocleidomastoids.

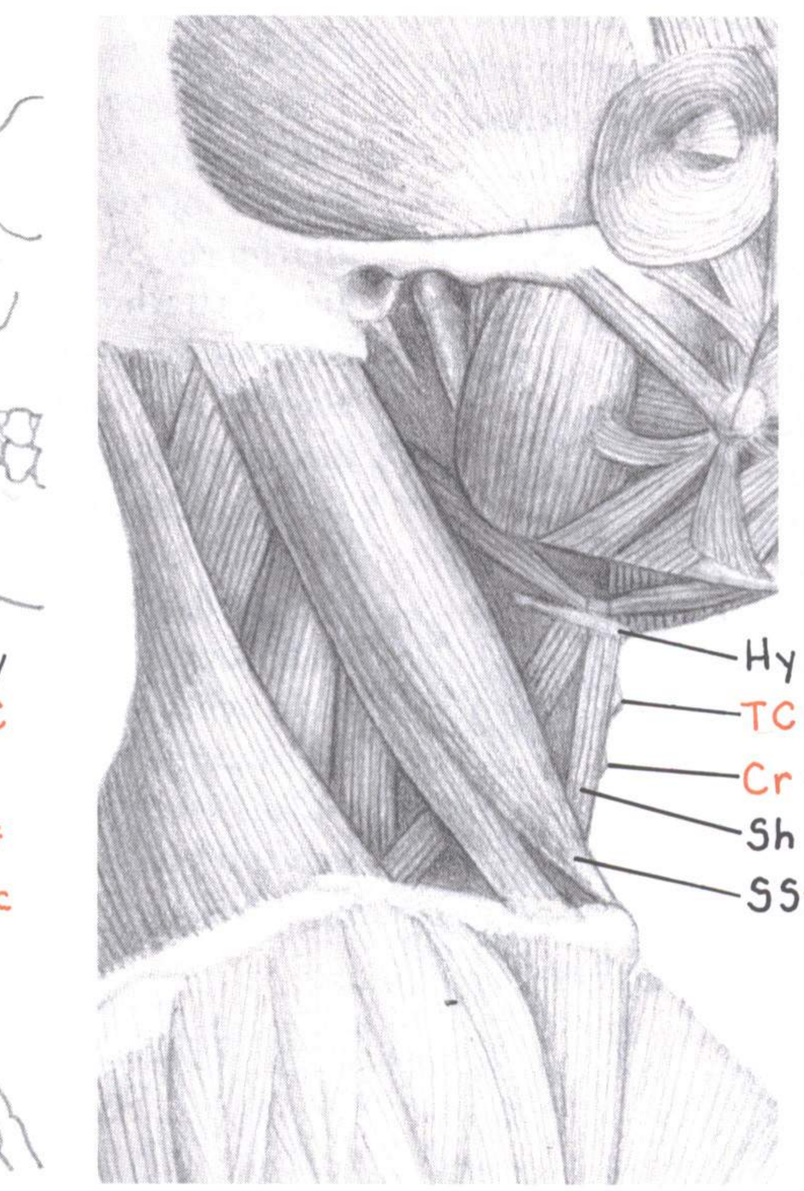


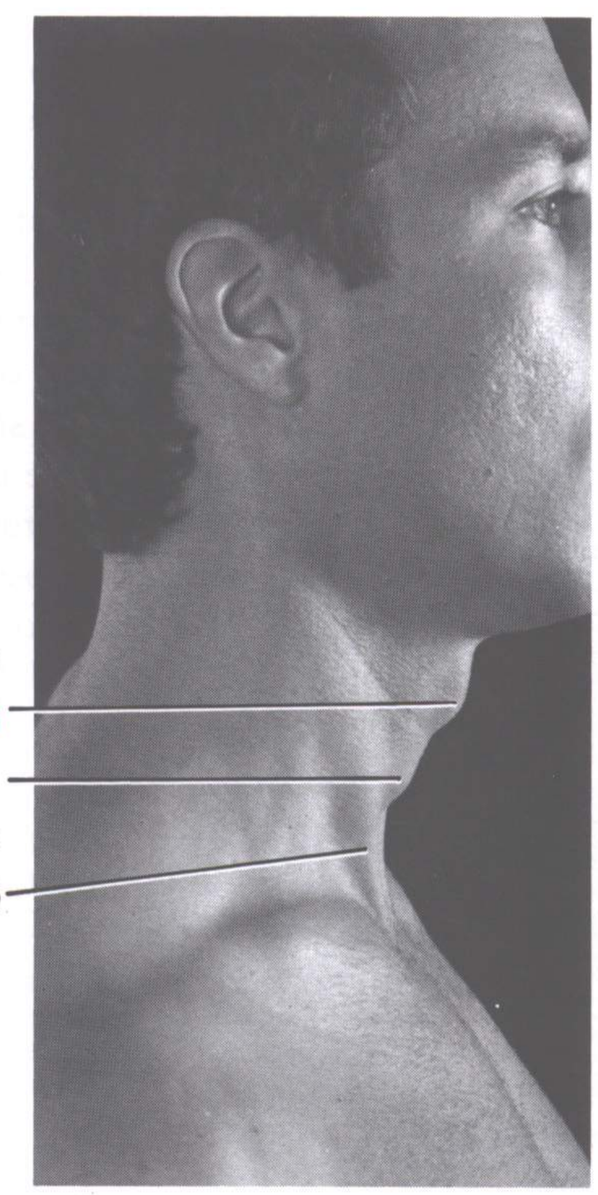




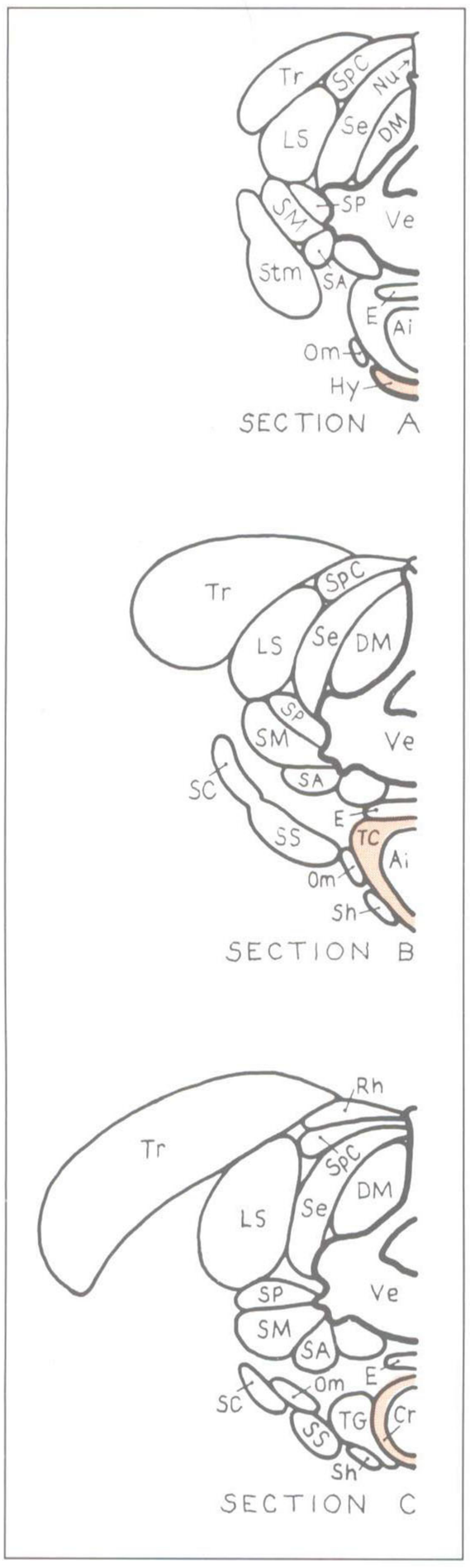








Ai *Air passage* **Cr** *Cricoid cartilage* **E** *Esophagus* **Hy** *Hyoid bone* **Om** *Omohyoid*
PN *Pit of neck* **Sh** *Sternohyoid* **SS** *Sternomastoid—sternal head* **Stm** *Sternomastoid*
TC *Thyroid cartilage* **TG** *Thyroid gland* **Trc** *Trachea* **Ve** *Vertebra*



The *THROAT* is the windpipe, or breathing tube, and consists of the larynx and trachea. The thyroid gland contributes to its form.

The throat is basically a semirigid cylindrical structure, located on the front of the neck, which connects the mouth to the lungs. The upper front edge of the throat cylinder is formed by the U-shaped hyoid bone (the hyoid bone inconspicuously lies at the junction between the bottom plane of the jaw and the front of the throat cylinder). The throat cylinder is directed downward and backward into the chest cavity to the lungs, passing behind the manubrium of the sternum. The cylinder is relatively wide—almost half the width of the neck—and lies between the bellies of the sternomastoid muscles. Because the throat cylinder tapers inferiorly, and because its lower portion is partially covered on the sides by the sternomastoids, it appears on the surface to be an inverted cone. It is also covered on its front by the straplike infrahyoid muscles (sternohyoids, omohyoids, etc.), which contribute to its cylindrical form.

As a unit, the throat moves up when the head is extended or the tongue protruded, and down when the head is flexed. During swallowing, it is pulled up to, and then drops down from, the hyoid bone. The throat cylinder has two bumps on its anterior surface: the thyroid cartilage on its upper third and the combined cricoid cartilage and thyroid gland on its middle third (the form of the cricoid cartilage predominates in the male; in the female, the thyroid gland is often most prominent). The trachea accounts for the lower third of the cylinder, but is not seen directly as it is covered by the skin draped over the structures of the lower portion of the throat. What remains is a concave depression at the pit of the neck. In the male, the upper bump is larger than the lower one. In the adult female, both bumps are more or less equal in size; sometimes both are inconspicuous, forming a simple curve along the front profile of the neck. The bumps become more prominent when the head and neck are extended.

The **larynx,** or "voice bŏx," consists, in part, of the thyroid cartilage, vocal cords, and cricoid cartilage.

The **thyroid cartilage** is the largest cartilage of the throat. Suspended by a membrane from the hyoid bone, it is shaped like the bow of a ship. Its two sides, or laminae, meet at a sharp angle to form its front edge (more acute and sharper in the male than in the female). In side view, the upper and lower portions of its front edge are cut back to produce a point on its anterior edge. The upper portion has an elongated V-shaped notch, which is easily palpated and often seen (especially in the extended head). The thyroid cartilage is larger and more prominent in the adult male than in the adult female, and is called the **Adam's apple.**

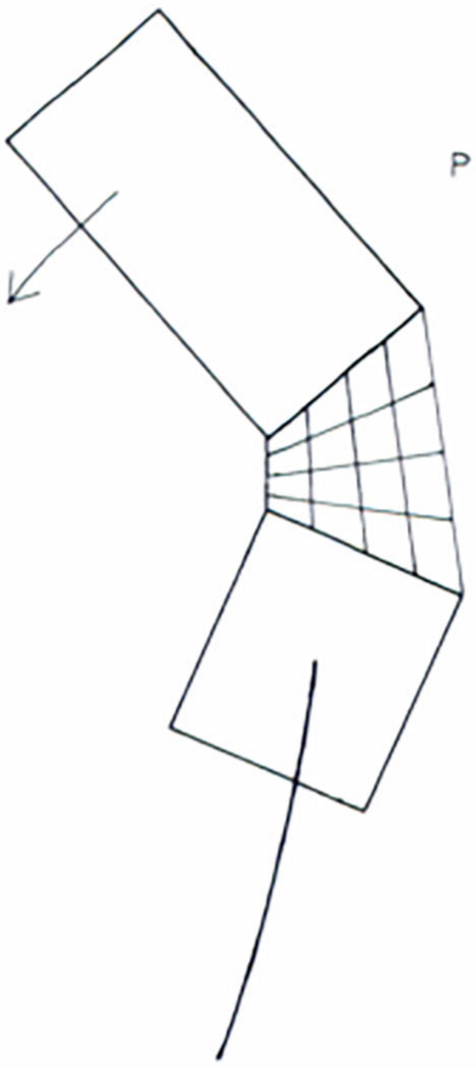
The **cricoid cartilage** is a cartilaginous ring located inferior to the considerably larger thyroid cartilage and superior to the narrower trachea. It has a wide U-shaped notch on the front of its upper edge, which registers as a subtle depression on the surface. The cricoid cartilage is subcutaneous and is visible in the male, where it creates the smaller, rounder, inferior bump on the front of the throat. In the female, its form is masked (although not covered) by the swelling of the larger thyroid gland.

The **thyroid gland** lies roughly at the level of the cricoid cartilage. It consists of a relatively large, oval lobe on each side of the throat (covered by the sternohyoids) connected in front by a narrow isthmus of gland across the upper portion of the trachea (over the second and third tracheal rings). The gland is visible in the adult female and in youth, where it creates the soft swelling of the inferior bump on the front of the neck, while concealing the cricoid cartilage. In men, the gland is usually inconspicuous.

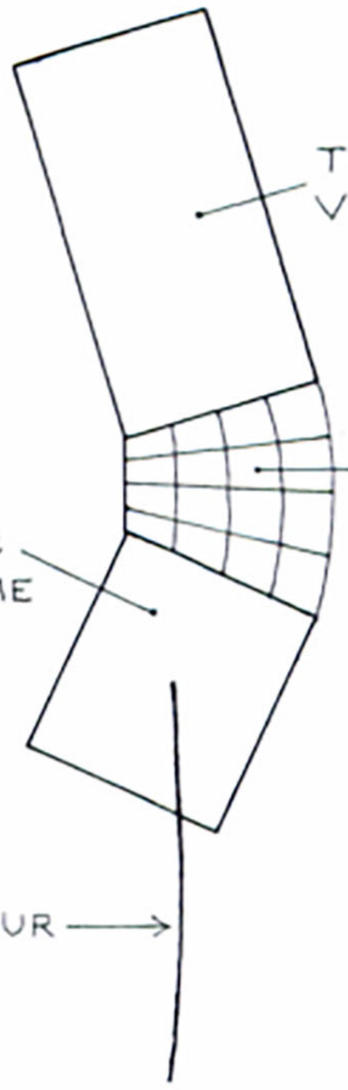
The **trachea,** beginning just below the cricoid cartilage, is the inferior component of the subcutaneous windpipe. It continues the form of the throat cylinder behind the sternum into the chest. Although its actual cylindrical form is concealed by the thyroid gland superiorly and the suprasternal fat inferiorly, it can easily be palpated. Its individual cartilaginous rings are not visible.

SIDE VIEW

POST. ⟷ ANT.



EXTENSION



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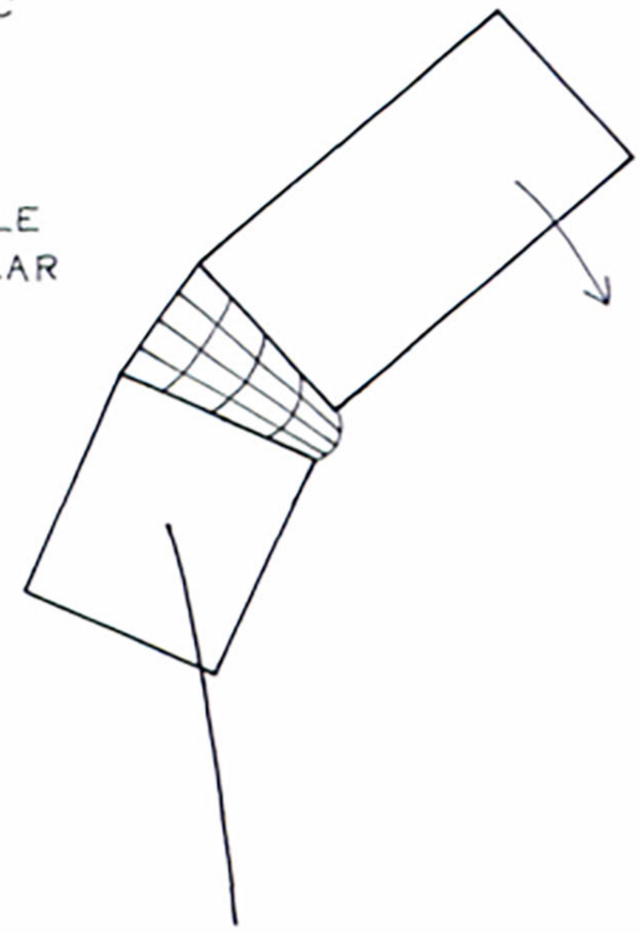
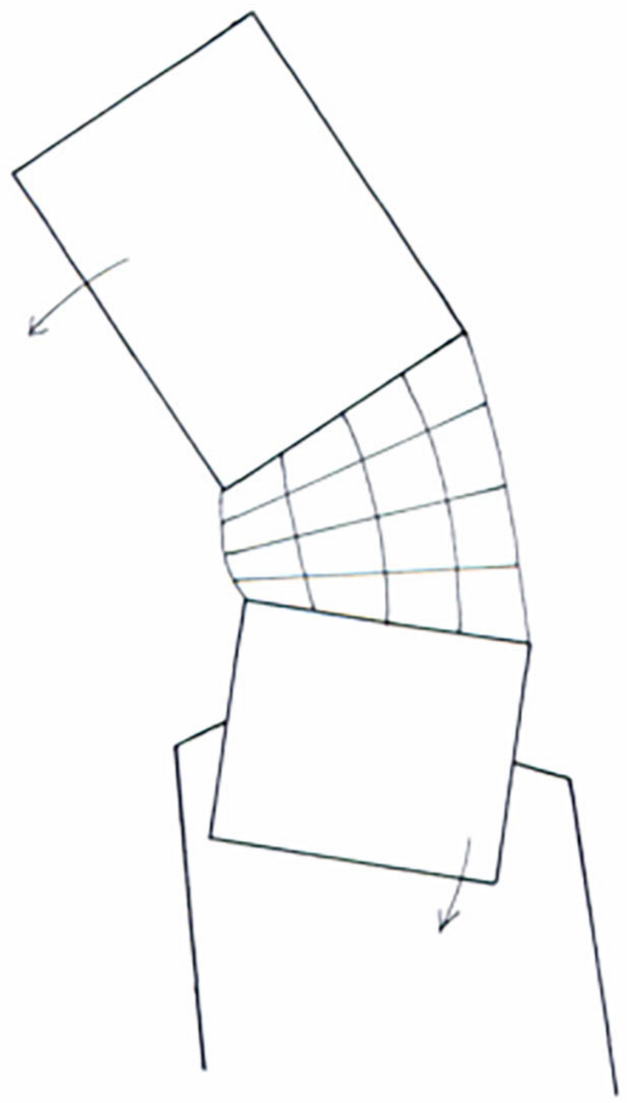
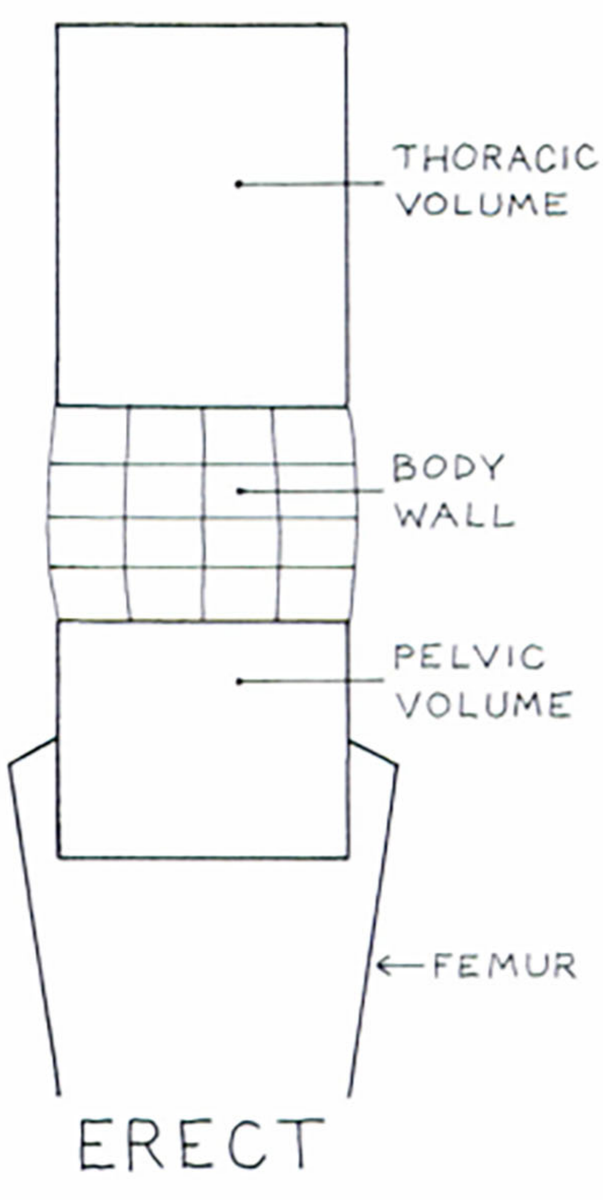


FLEXION

FRONT VIEW



LATERAL BENDING



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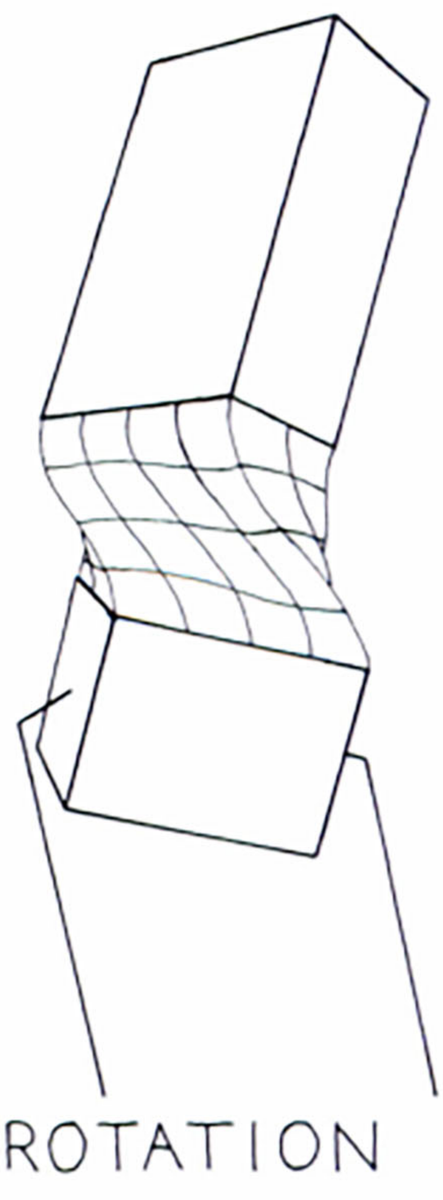


ROTATION

The Trunk Muscles

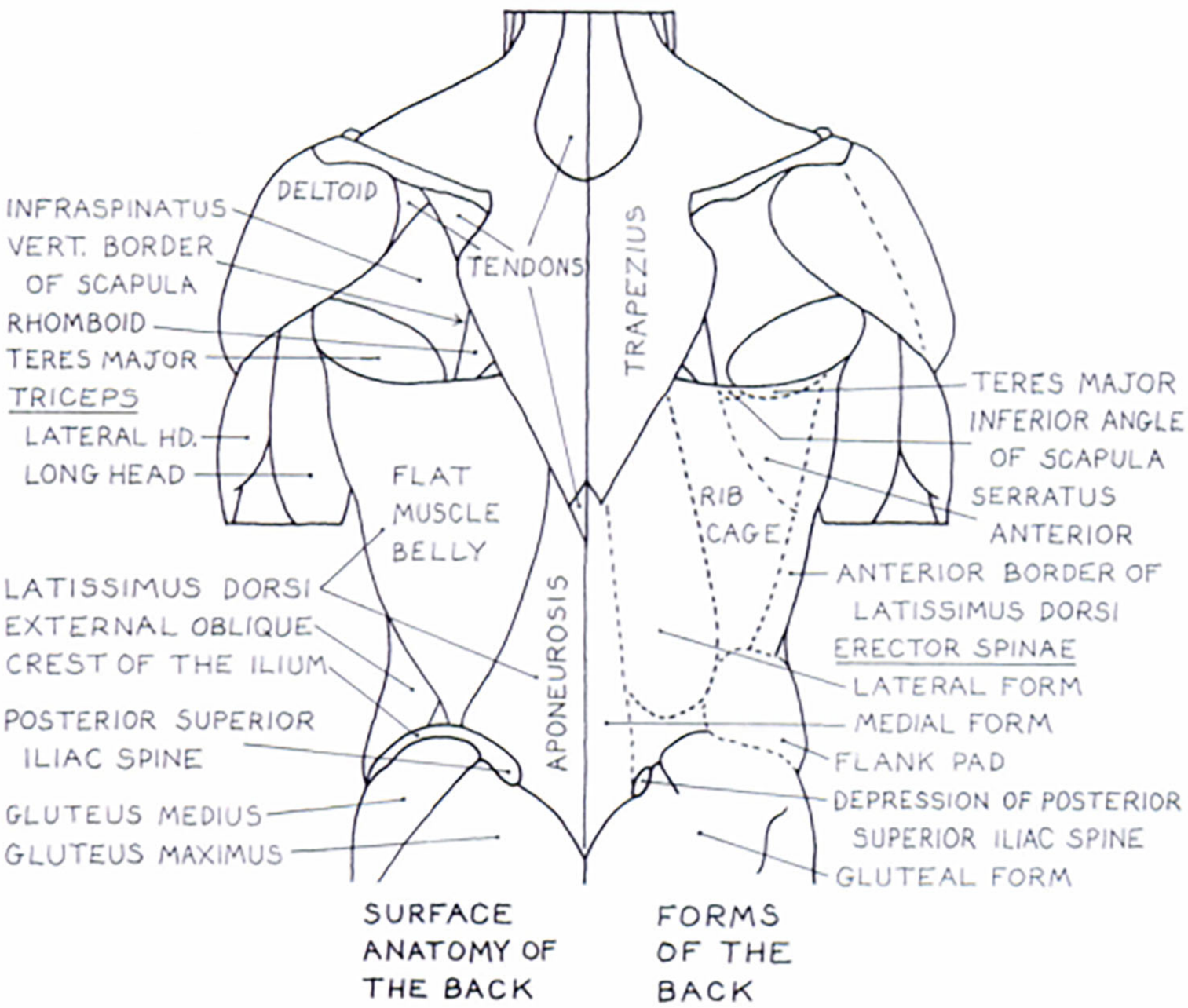
The region from the shoulders to the iliac lines is considered the trunk. The *TRUNK MUSCLES*, described on the following pages, for the most part lie on the trunk itself, although some cross the shoulder joint and the neck.

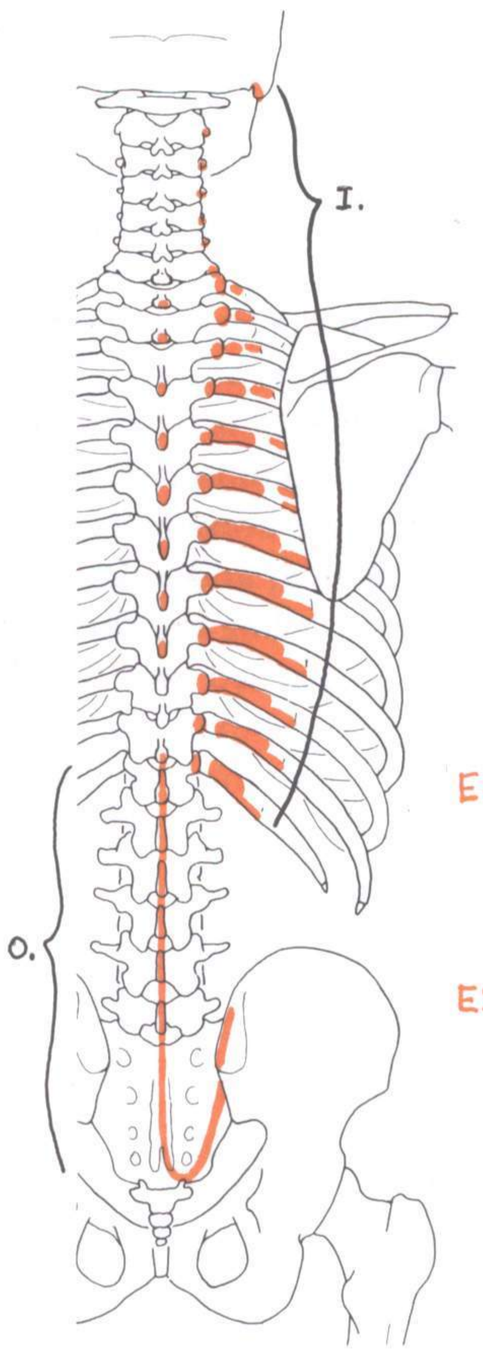
The shape of the trunk is largely determined by the rib cage, upon which the pyramidal shoulder apparatus of both sides—the bony shoulder girdles and their muscles—sit and glide. The trunk is flattened from front to back, noteworthy in the human figure because in quadruped mammals the torso is laterally compressed from side to side.

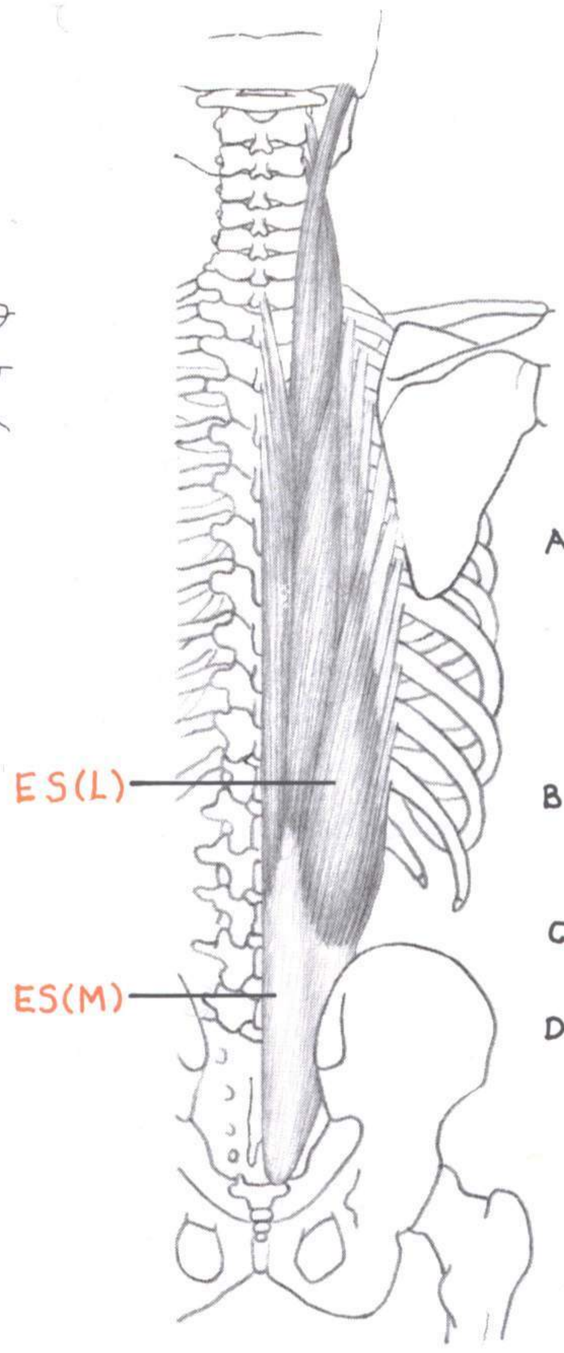
The rigid rib cage is separated from the pelvic region (the rigid upper margin of the pelvis) by the muscular body wall. These "rigid units" are independent of and often dynamically opposed to each other. They are connected by the lumbar vertebrae in back, which allow, and also limit, the movements possible between them.

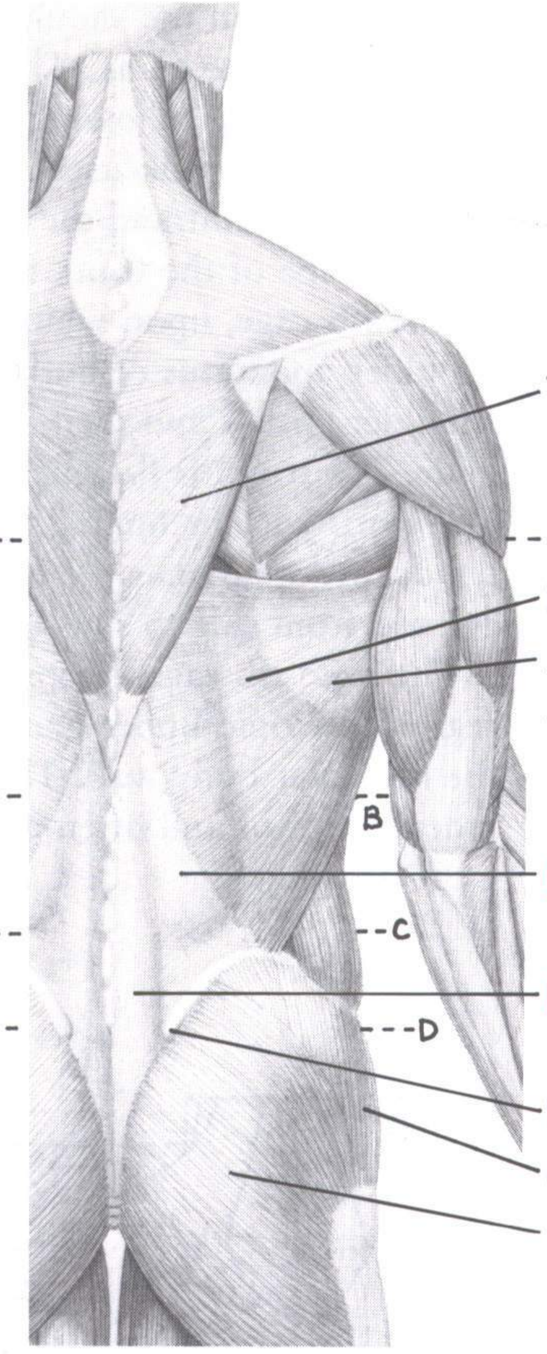
The irregularly shaped interval between the two bony regions (between the bottom of the rib cage and the top of the pelvis) is bridged by the thin, soft, **muscular body wall,** made up of the rectus abdominis and the external oblique (as well as other thin layers of deeper muscles). These muscles accommodate all the twisting and bending of the bony regions by stretching, contracting, folding, and bulging.

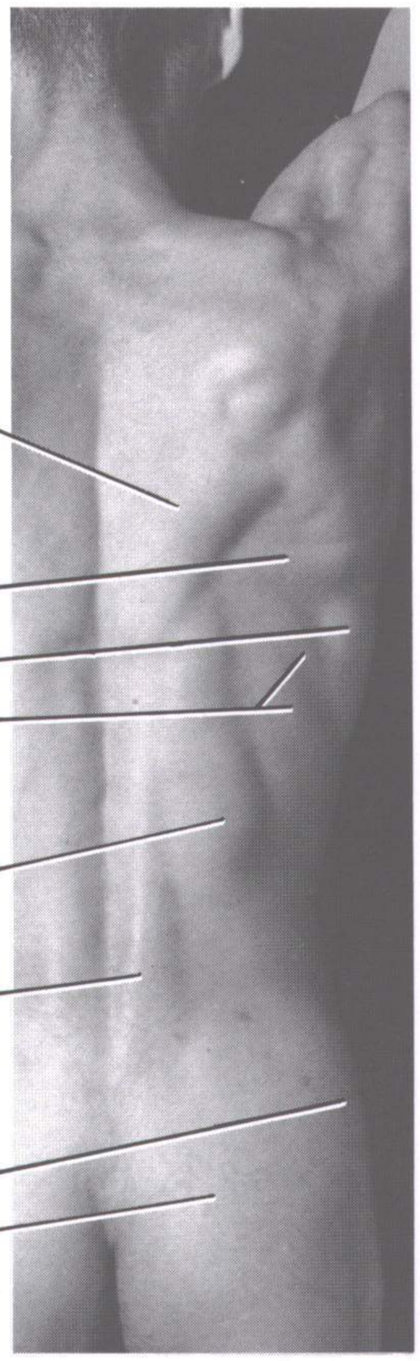
The trunk (including the shoulders) is easily visualized as a flattened box. The back of the trunk appears larger than the front, and can be visualized as an inferiorly pointed triangular wedge, especially in the male.

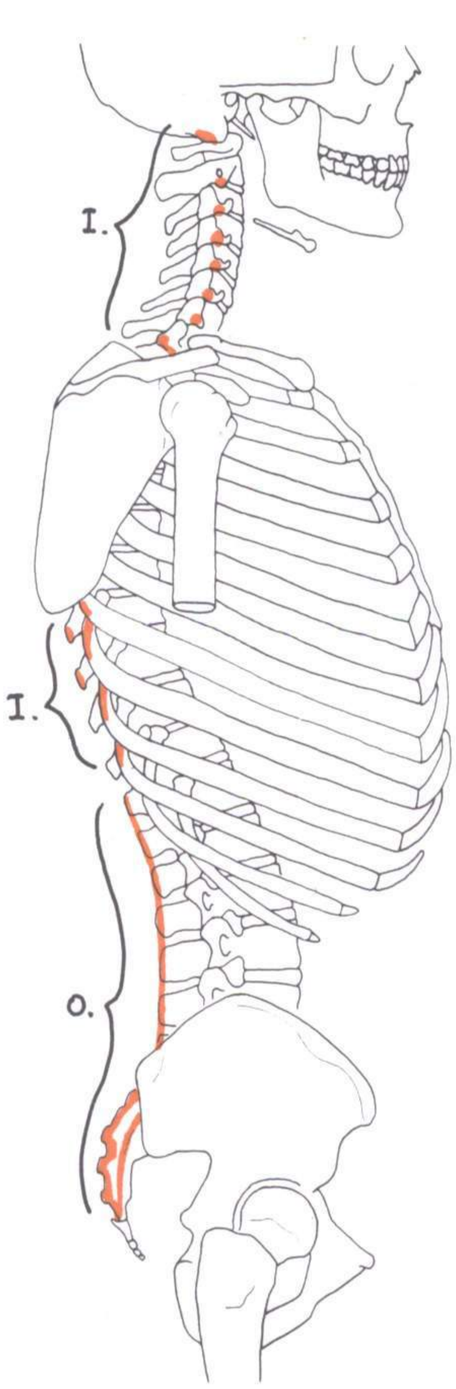


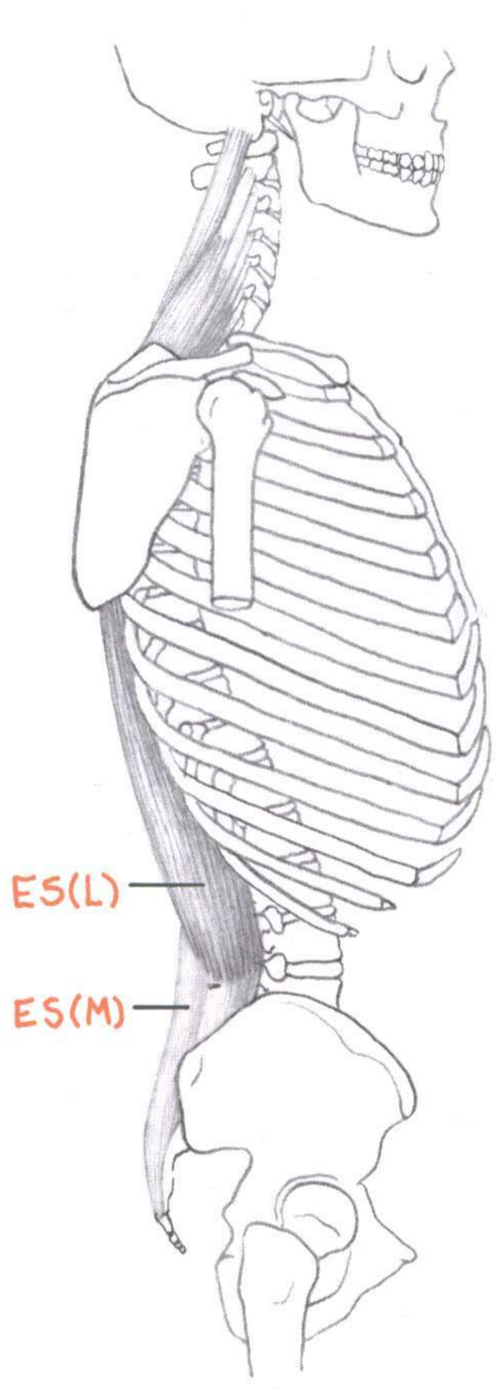


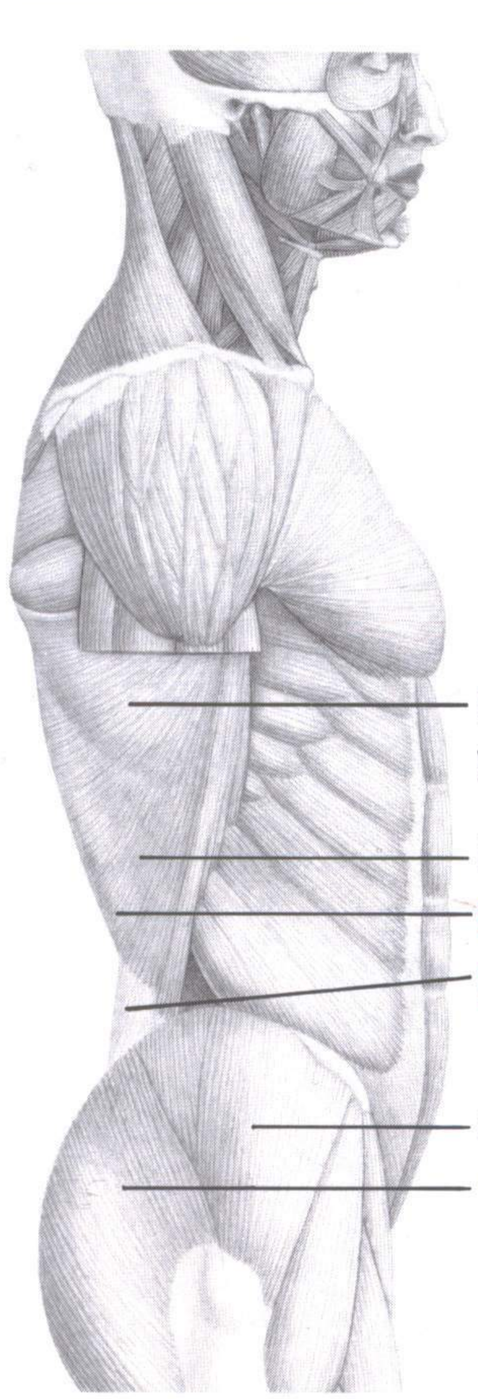


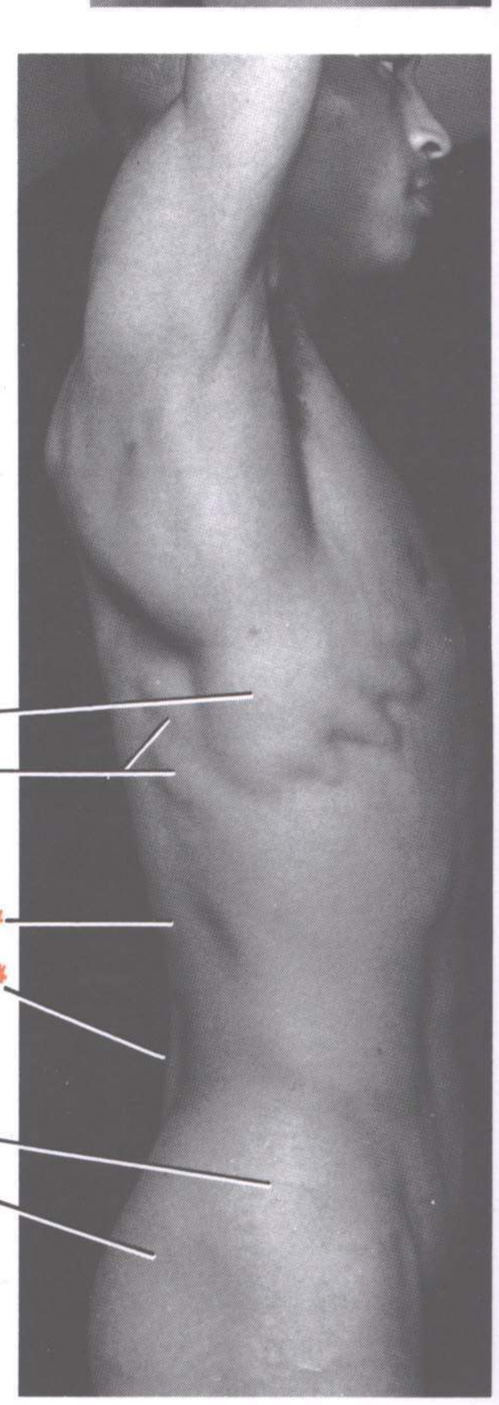




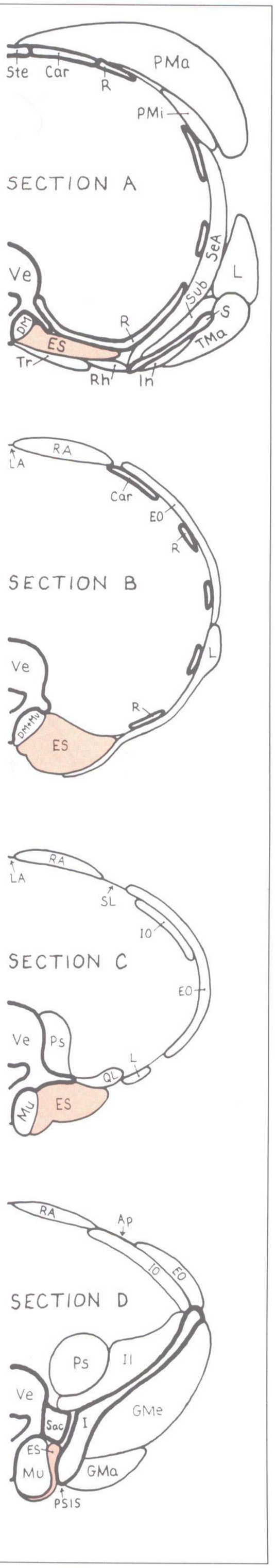








DM *Deep muscle* **ES** *Erector spinae* **ES(L)** *Erector spinae—lateral form*
ES(M) *Erector spinae—medial form* **FF** *Flank fat pad* **GMa** *Gluteus maximus* **GMe** *Gluteus medius*
I *Ilium* **L** *Latissimus dorsi* **Mu** *Multifidus* **PSIS** *Posterior superior iliac spine*
QL *Quadratus lumborum* **R** *Ribs* **Sac** *Sacrum* **SeA** *Serratus anterior* **Tr** *Trapezius* **Ve** *Vertebra*
* *Under latissimus dorsi*



Erector Spinae (Sacrospinalis)

ORIGIN A continuous line which begins on the inner surface of the posterior third of the iliac crest, passes down the lateral *crest* of the sacrum (not the lateral edge), curves around to and then up the median crest of the sacrum (on the midline), and continues straight up the tips of the spinous processes and supraspinal ligament of the lumbar and lower two thoracic vertebrae. (There are additional deep sites of origin further up the back.)

INSERTION By many muscular slips into numerous points on the backs of all twelve ribs, between the *angles of the ribs laterally* and the *tubercles of the ribs medially;* into the spinous and/or transverse processes of all the thoracic and cervical vertebrae; and into the mastoid process of the skull.

ACTION Extends the vertebral column and the head. Portions of the erector spinae assist in rotation and lateral flexion of the vertebral column.

STRUCTURE The erector spinae, or **sacrospinalis** consists of several combined muscles which form a thick, elongated muscle mass on the back to the side of the spinous processes of the vertebral column. It extends from the sacrum to the base of the skull. It is thickest in the lumbar and cervical regions, and thinner and wider in the thoracic region. In the thoracic region, it widens out to, but not past, the angles of the ribs. At about the level of the bottom of the scapula, its form becomes less distinct as it thins and passes upward under the rhomboids and the trapezius.

In the side view of the body, the back profile of the muscle creates a transition between the *down plane* of the back of the thorax and the *up plane* of the back of the sacrum. The back profile usually appears as a series of two convexities, as the erector spinae separates into medial and lateral forms (see below). The lumbar portion of the erector spinae forms a powerful and prominent muscular column on each side of the spine in the lower back, referred to as the **strong cords** or the **common mass.**

The erector spinae is simple and tendinous at its origin. As it ascends, it divides into several muscles which split into numerous bundles; new fibers arise as lower fibers insert. The separate muscles and bundles are occasionally seen on the surface—usually momentarily during motion.

When the figure is standing erect, and the erector spinae is relaxed, the muscle appears as a *single wide muscular form* on either side of the median spinal furrow (the depressed ridge of the spinous processes). As the thorax flexes forward at the waist, the muscle immediately tenses and hardens, and the cylindrical form of *each side* divides into *two* forms—a narrow, lower, vertical medial form and a wider, higher, oblique lateral form.

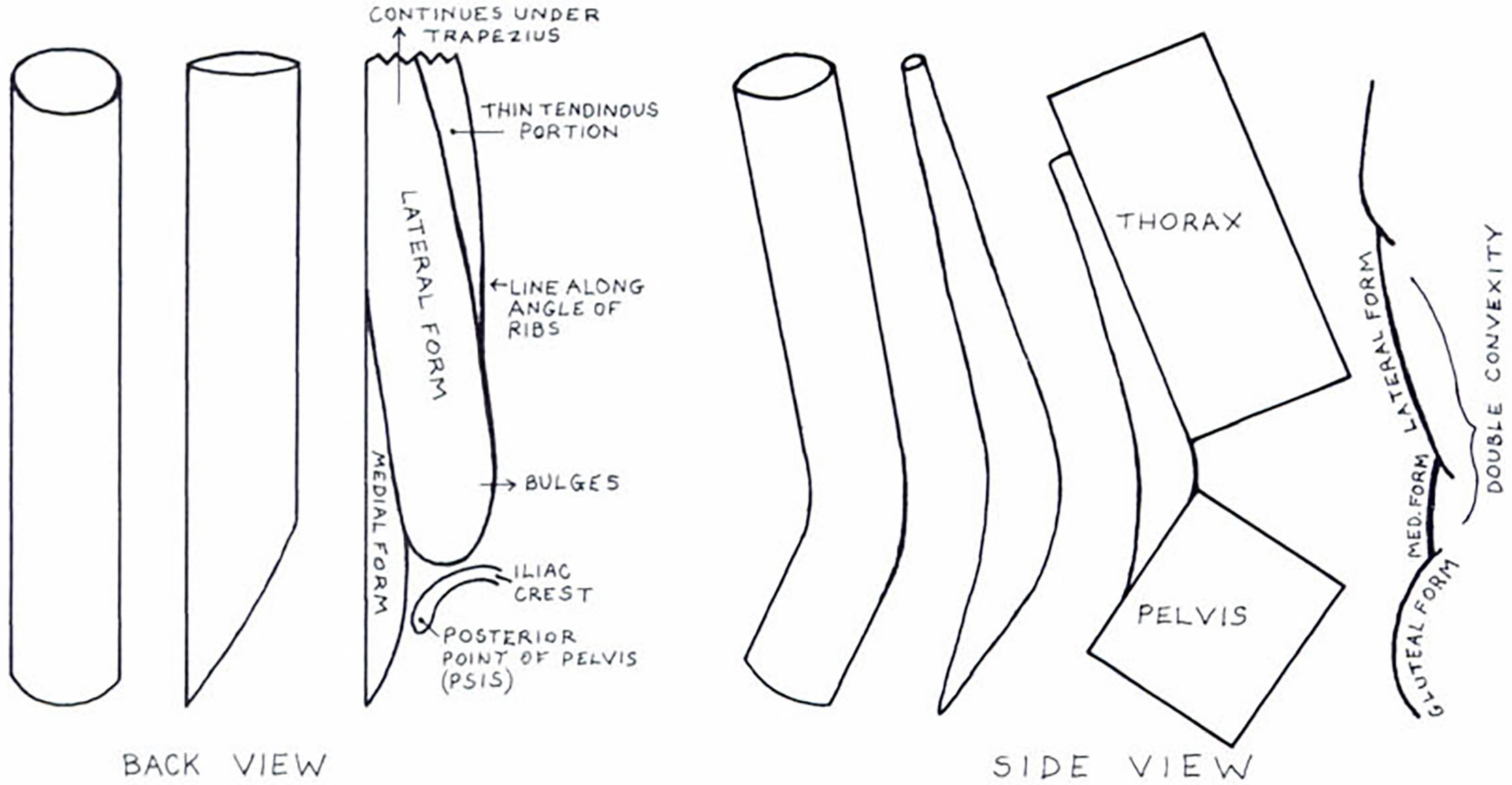
The **medial form** is made of the multifidus muscle inferiorly (lying under the tendon of the erector spinae) and part of the belly of the erector spinae superiorly. This form begins mid-sacrum, slightly below the level of the posterior superior iliac spine, and ends superiorly just below the lower tip of the trapezius. It lies between the spinous processes of the lumbar vertebrae and the depression (or bump) of the posterior superior iliac spine. The inferior end of the medial form widens slightly on the posterior surface of the sacrum.

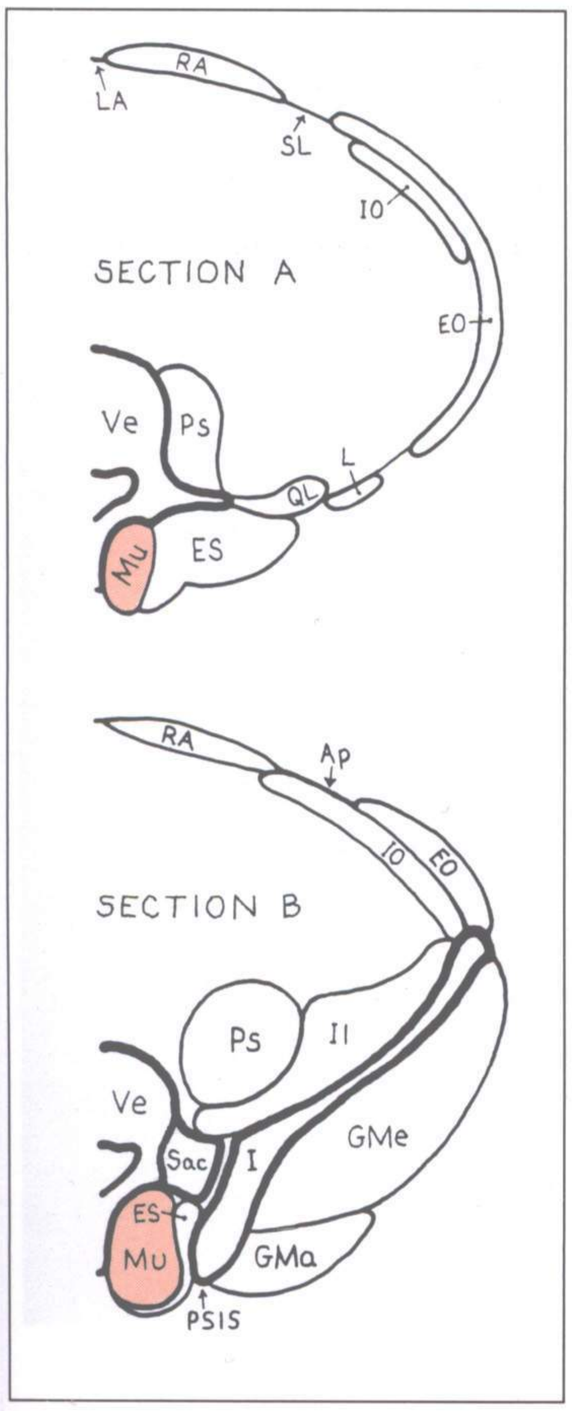
The **lateral form** begins inferiorly at the level of the top of the crest of the ilium and disappears superiorly at the level of the bottom of the scapula, where it thins out and passes under the trapezius (it is occasionally seen higher, bulging under the trapezius). This form is oblique, being directed upward and slightly medially. It is made up of fleshy muscle fibers of the erector spinae. The lateral form is usually wider inferiorly (the portion of the belly between the rib cage and the pelvis bulges laterally because of the fullness of the muscle). It narrows superiorly (its lateral edge shifts medially) as the ascending muscle bundles along its lateral side thin into nonvisible tendons. The tendons continue to insert out to the angles of the ribs, but the visible form does not extend that far laterally. The lower end of the lateral form is created where its fleshy fibers attach into its wide tendon of origin.

As the trunk reaches full flexion (flexing at the vertebral column, not at the hip joints), the erector spinae is pulled relatively thin and flat, and the spinous processes of the lumbar and sacral vertebrae, as well as the posterior superior iliac spines, begin to project. When the figure is erect, the vertical median furrow of the back (at the bottom of which lie the vertebral spinous processes) ends inferiorly halfway down the sacrum.

The latissimus dorsi may confuse the shape of the erector spinae in two ways. First, if the erector spinae is relaxed when the latissimus dorsi is tensed, the latissimus pulls on its wide, sheetlike tendon of origin (also called the thoracolumbar fascia), which lies on the surface of the erector spinae. This pulling causes ridges or furrows to develop across the long axis of the soft erector spinae. These ridges are in line with the direction of the muscle fibers of the latissimus, and are therefore almost horizontal superiorly and more oblique inferiorly. Second, when

the latissimus is tensed, the line of attachment of its muscle fibers into its wide tendon of origin occasionally becomes visible—its muscle fibers are in slight raised relief where they meet the tendon. This visible diagonal line, either curved or straight, sits *on top of the lateral form of the erector spinae*. It is located lateral to the oblique line which separates the erector spinae into its medial and lateral forms. The latissimus line appears only when the latissimus dorsi is tensed, regardless of whether the erector spinae is relaxed or contracted.





Multifidus
(Multifidi)

ORIGIN The medial half of the posterior surface of the sacrum, the inner aspect of the posterior superior iliac spine, the posterior sacroiliac ligaments, and various points on the back of the lateral processes of all the vertebrae except the first three cervical vertebrae.

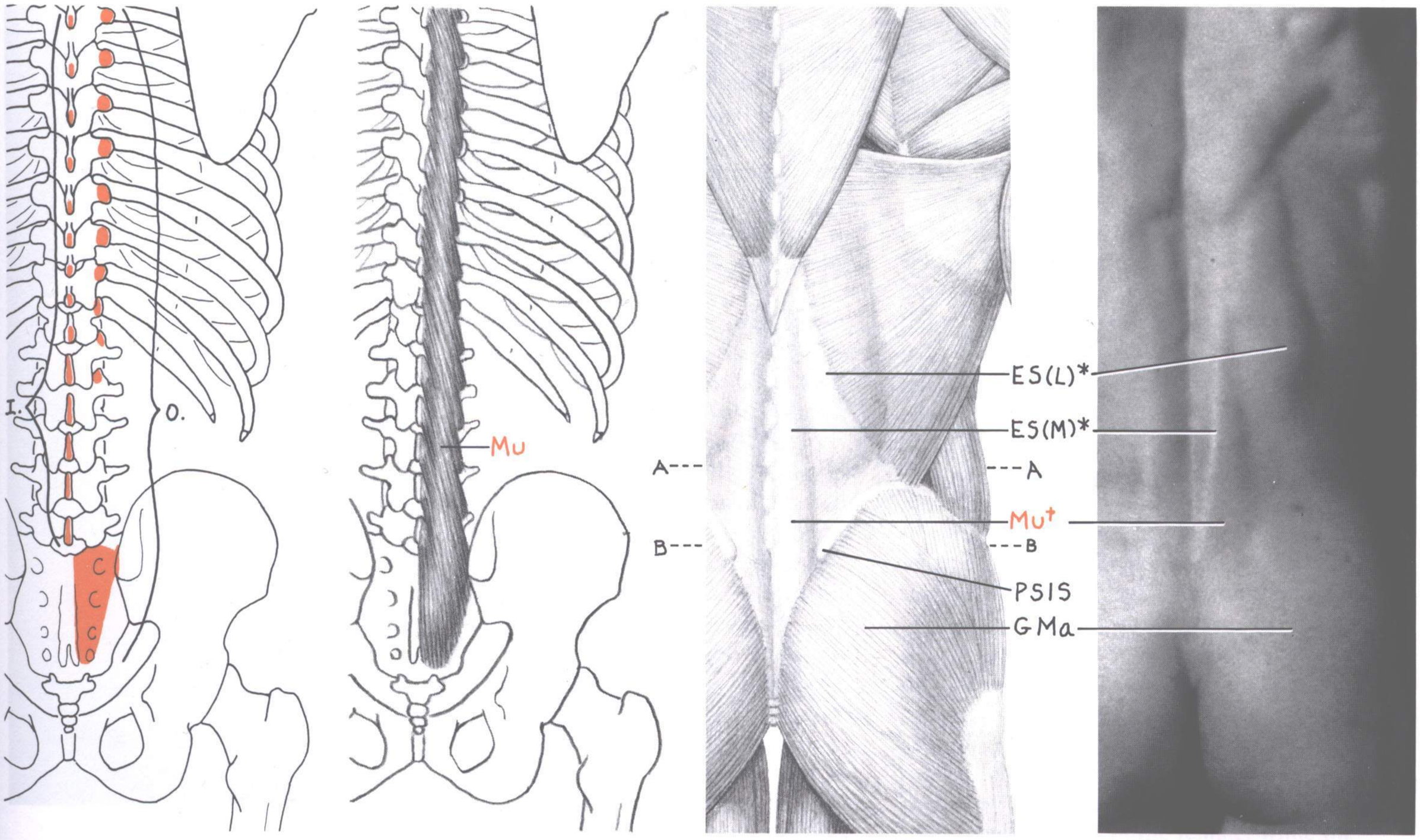
INSERTION The spinous processes of all the vertebrae, except the atlas.

ACTION Extends, laterally flexes, and rotates the vertebral column.

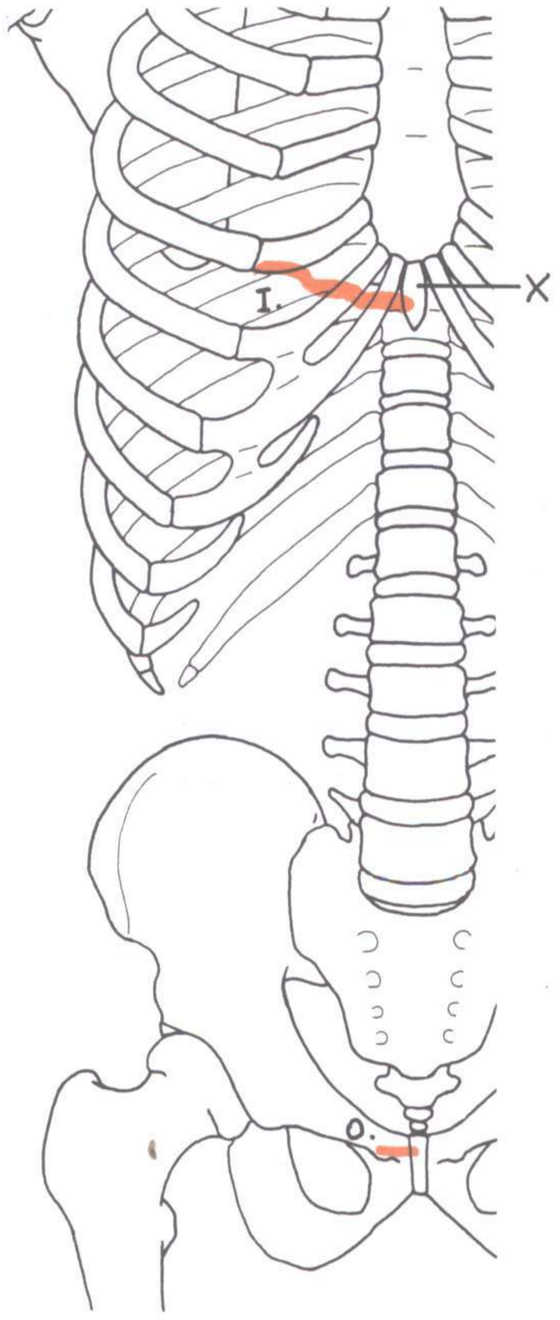
STRUCTURE The multifidus (multifidi) lies *deep* to the erector spinae. It fills the bony groove on both sides of the spinous processes of the vertebrae along the *entire* vertebral column. It consists of numerous short bundles passing obliquely upward and medially. They variously cross over two to five vertebrae at a time, depending on their length, to insert into a higher vertebra.

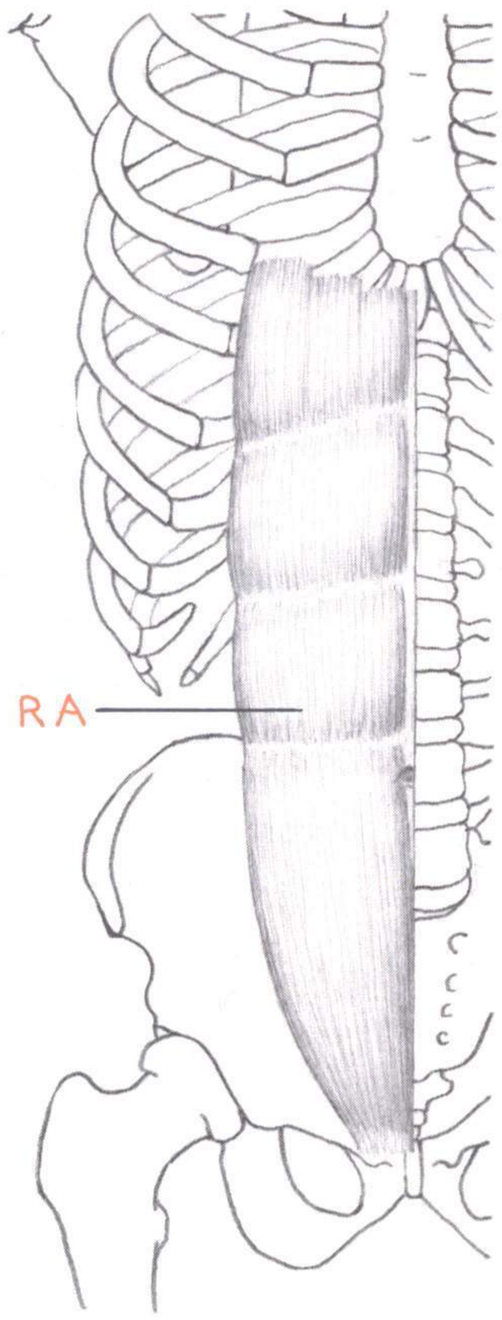
The upper portion of the muscle is deep to the other spinal muscles. It progressively becomes thicker and wider as it descends. Inferiorly, it is covered only by the tendon of the erector spinae in the lower lumbar and sacral region. The gluteus maximus originates in part from the surface of the lateral portion of this tendon. The multifidus therefore directly creates surface form in the lower lumbar and sacral areas.

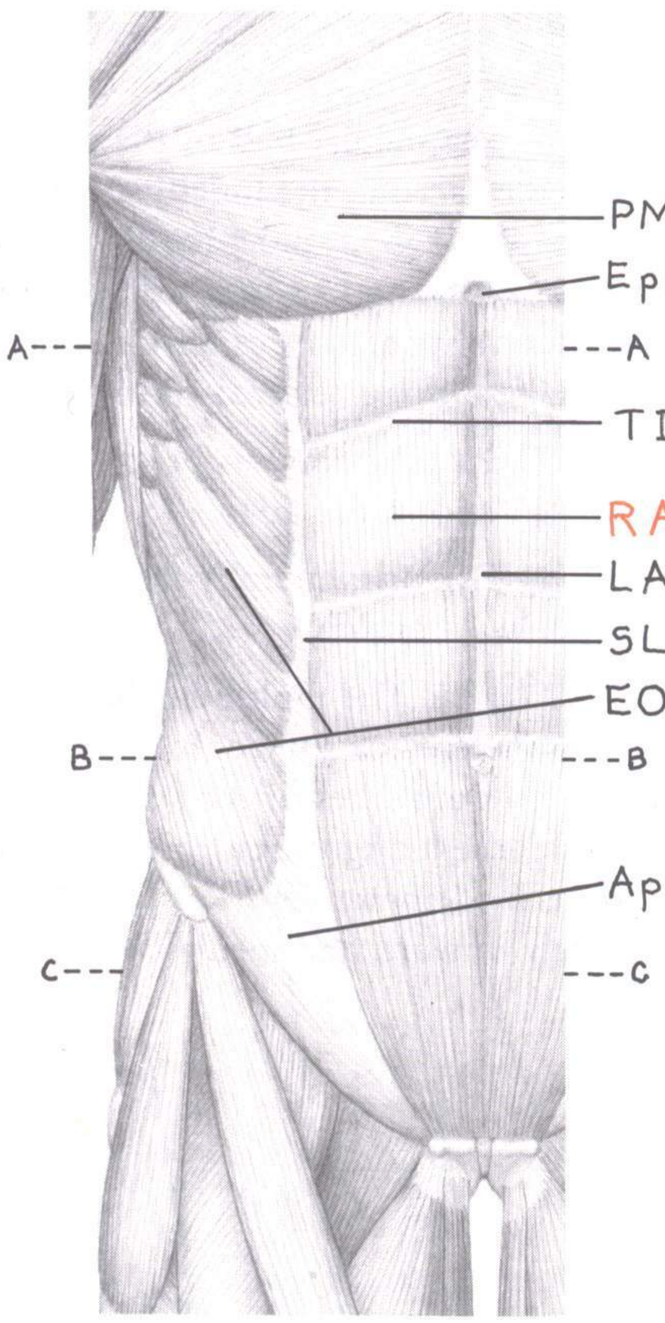
When the back muscles are tensed, the multifidus creates the lower portion of the narrow vertical form that lies immediately on either side of the spinous processes of the sacrum and lumbar vertebrae.

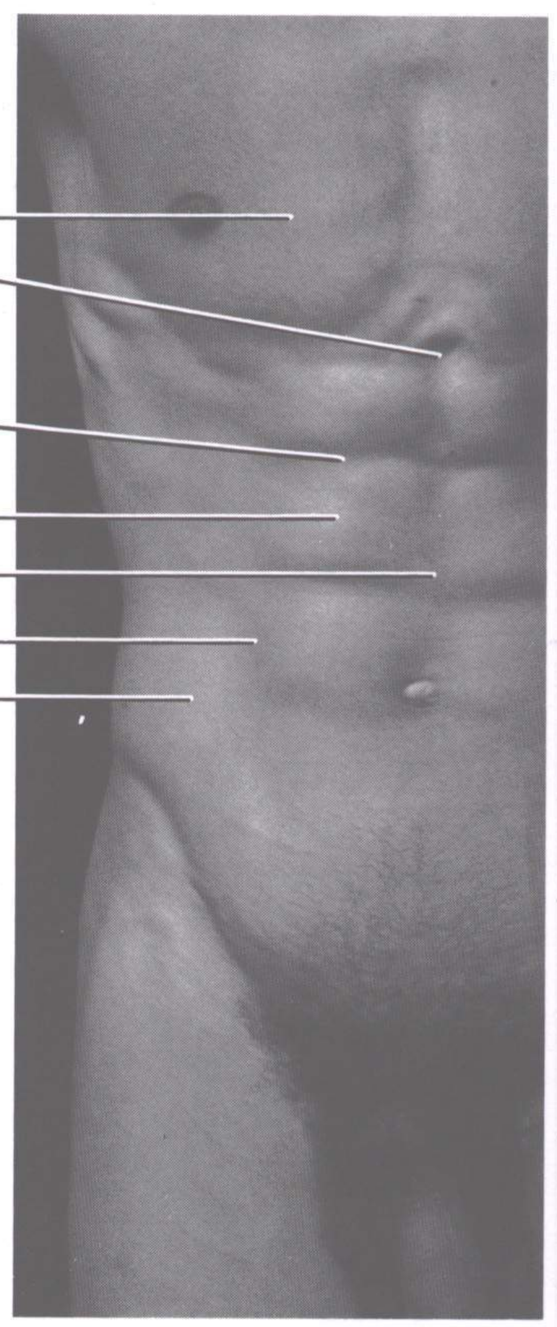


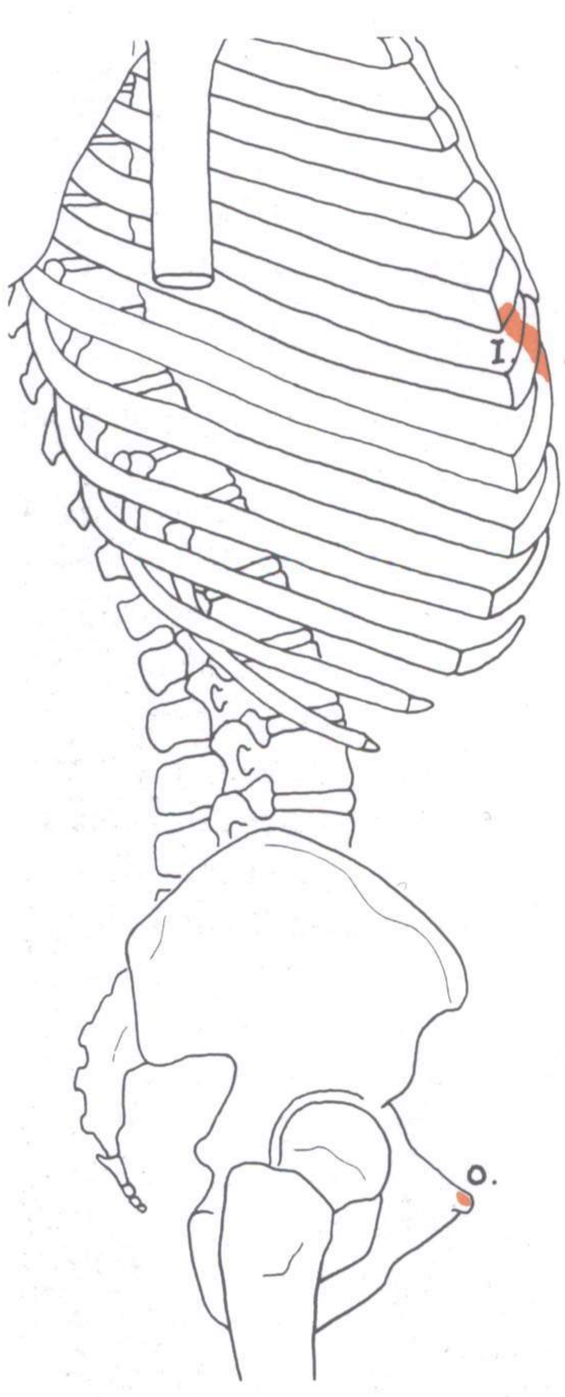
ES *Erector spinae* **ES(L)** *Erector spinae—lateral form* **ES(M)** *Erector spinae—medial form*
GMa *Gluteus maximus* **Mu** *Multifidus* **PSIS** *Posterior superior iliac spine* **Sac** *Sacrum* **Ve** *Vertebra*
* *Under latissimus dorsi* † *Under erector spinae*

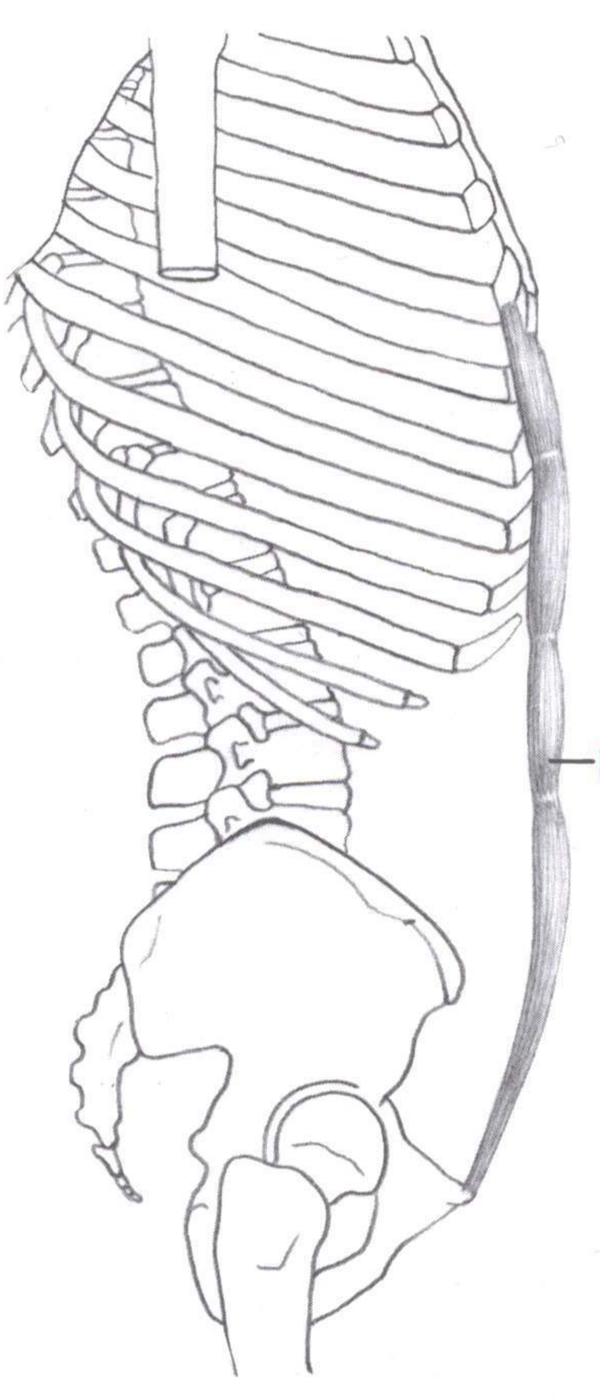


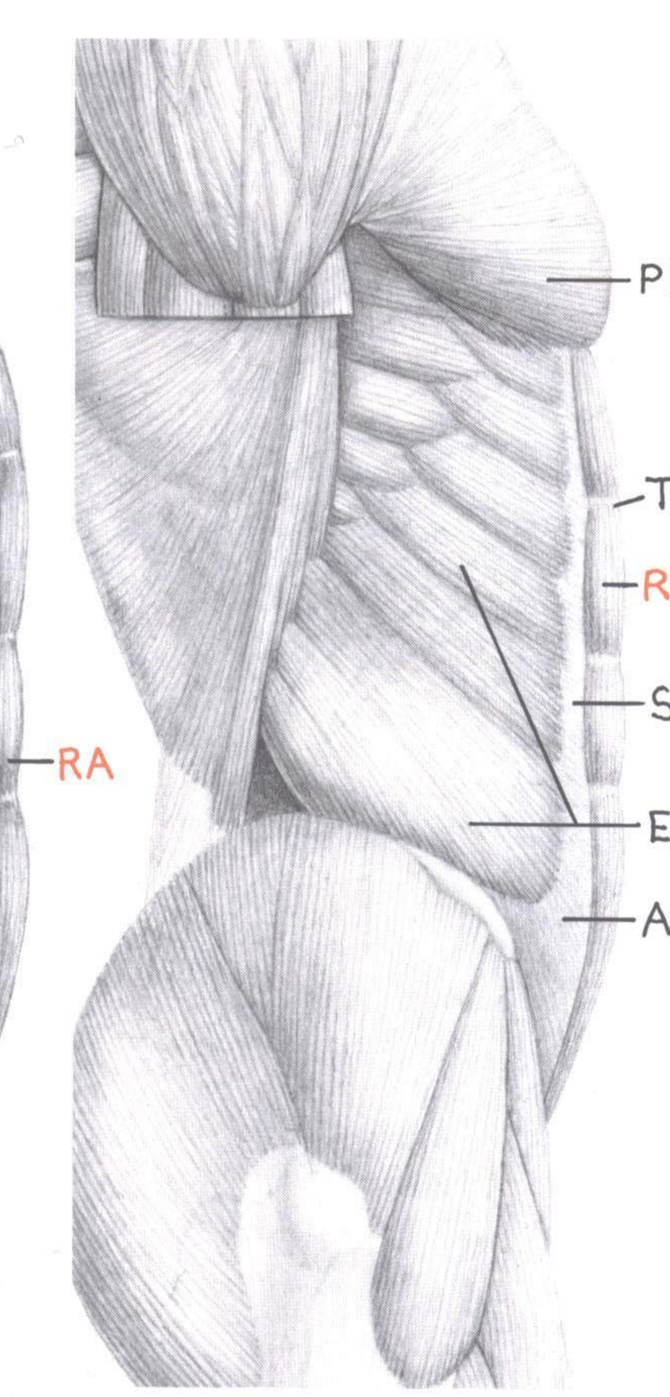


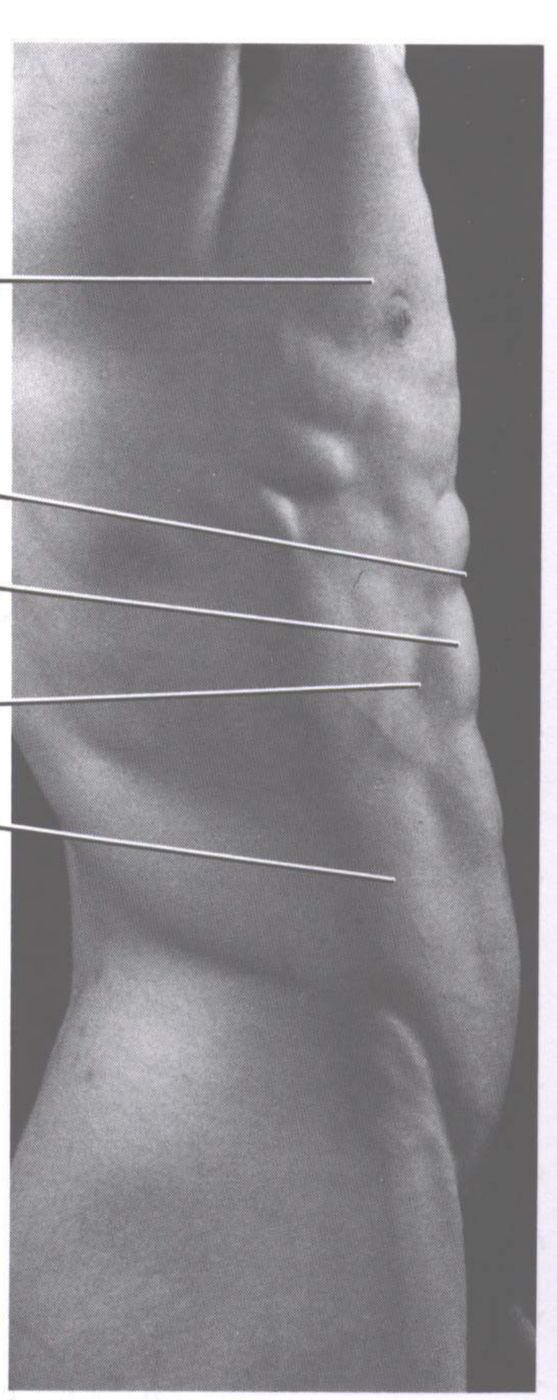




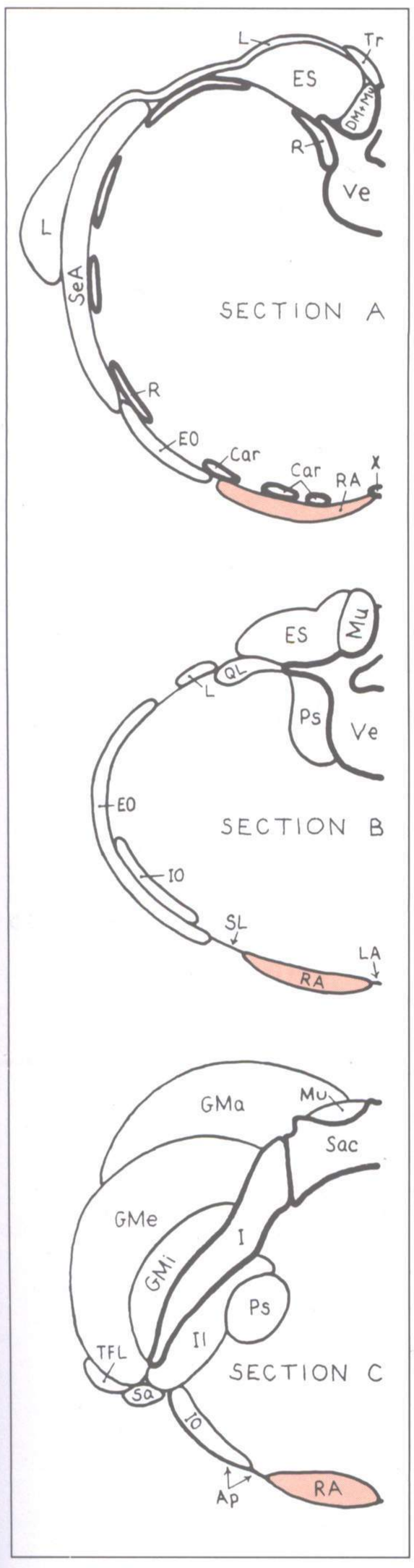








Ap *Aponeurosis* **Car** *Cartilage* **EO** *External oblique* **EpD** *Epigastric depression* **IO** *Internal oblique*
LA *Linea alba* **PMa** *Pectoralis major* **RA** *Rectus abdominis* **SL** *Semilunar line*
TI *Tendinous intersection* **X** *Xiphoid process*



Rectus Abdominis

ORIGIN Pubic crest of the pubic bone (a short horizontal line at the top of the pubic symphysis) and from ligaments on the front of the pubic symphysis.

INSERTION Anterior surfaces of the costal cartilages of the fifth, sixth, and seventh ribs and the anterior surface of the xiphoid process.

ACTION Flexes the trunk at the lumbar vertebrae.

STRUCTURE The rectus abdominis is a long, flat, vertical muscle on the front of the abdomen. It is wide and thin above and tapers below. The muscles of each side of the body meet at the midline at a tendinous vertical line, the **linea alba** (white line), which extends from the xiphoid process to the pubis. The linea alba appears as a vertical furrow between the two bellies, gradually disappearing below the navel. The navel is variably situated halfway to two-thirds of the way down this line. During lateral trunk flexion, only the portion of the linea alba above the navel curves laterally (corresponding to the curving lumbar vertebrae in back).

The lateral edge of the rectus abdominis is separated from the fibers of the external oblique by a tendinous furrow called the **semilunar line.** It is located *medial* to a line dropped from the nipple (or straight down from mid-clavicle) which is directed downward toward the *middle* of the thigh (in the anatomical position). The semilunar line begins just below the lower border of pectoralis major (on the surface of the rib cage, where it is faint) and continues downward beyond the rib cage, where it is more pronounced. Inferiorly, at the level of the navel, the semilunar line begins to widen into a tendinous triangular expansion.

Usually, three fibrous bands, the **tendinous intersections,** are situated in the muscle and inscribe transverse furrows across the belly. They do not necessarily pass straight across both rectus abdominis muscles, but are sometimes located at different levels on each side, giving the abdomen an asymmetrical appearance. An individual intersection may be either straight or zigzag. Classically, the lowest tendinous intersection is horizontal and is located at, or slightly above, the level of the navel. The highest is diagonal and is directed *approximately* from the tip of the xiphoid process to the point where the semilunar line crosses the ninth costal cartilage. The middle tendinous intersection is located at or above the level of the waist, and its degree of obliquity is midway between the other two. Occasionally a fourth tendinous intersection is found below the navel, but is not always seen. The obliquity of the intersections is highly variable, and they may all be horizontal.

The three tendinous intersections divide the rectus abdominis into four fleshy, muscular **segments.** The superior segment is continued upward over the costal cartilage on the front of the rib cage and is the least conspicuous of the four. Its upper edge usually coincides with the lower border of the pectoralis major; therefore, this segment ends before reaching the bottom of the sternum, leaving the infrasternal notch (epigastric depression) exposed. It may end higher, continuing under the pectoralis, or lower, exposing costal cartilage. Sometimes this segment divides into three vertical bundles of unequal length, progressively becoming longer and inserting higher laterally. The overall plane of the upper segment is directed slightly upward. The medial bundle of this segment attaches into the seventh cartilage; the middle bundle, into the sixth; and the lateral bundle, into the fifth cartilage and its bony rib. The lowest segment—long and tapering inferiorly—bulges the most. This segment is part of the pelvic volume, and the segments of the two sides of the body are usually not separated by the linea alba. The corners of all the segments are slightly rounded.

The *rounded* **abdominal** or **Greek arch,** as configured in classical Greek sculpture, is complicated, and is composed of several structures—cartilage, muscle belly, and tendinous intersection. It begins laterally and inferiorly at the costal cartilages of the ribs (from the tenth rib) and continues up and over *through the uppermost tendinous intersection* of the rectus abdominis. The upper most fleshy segments of the rectus abdominis of both sides bulge above the tendinous intersection and fill the sharp, angular summit between the two sides of the upper ends of the costal cartilages, where they meet the lower end of the sternum at an angle of 90° (more acute in the female). The tip of the xiphoid process projects forward, pushing muscle and tendinous intersection anteriorly, which also helps to round off the abdominal arch. Since the rectus abdominis muscle belly crosses *over* the costal cartilage, in muscular individuals the entire form of the upper segment may predominate and be seen as a distinct fleshy bulge, whereas in thin individuals the form of the underlying costal cartilage may predominate.

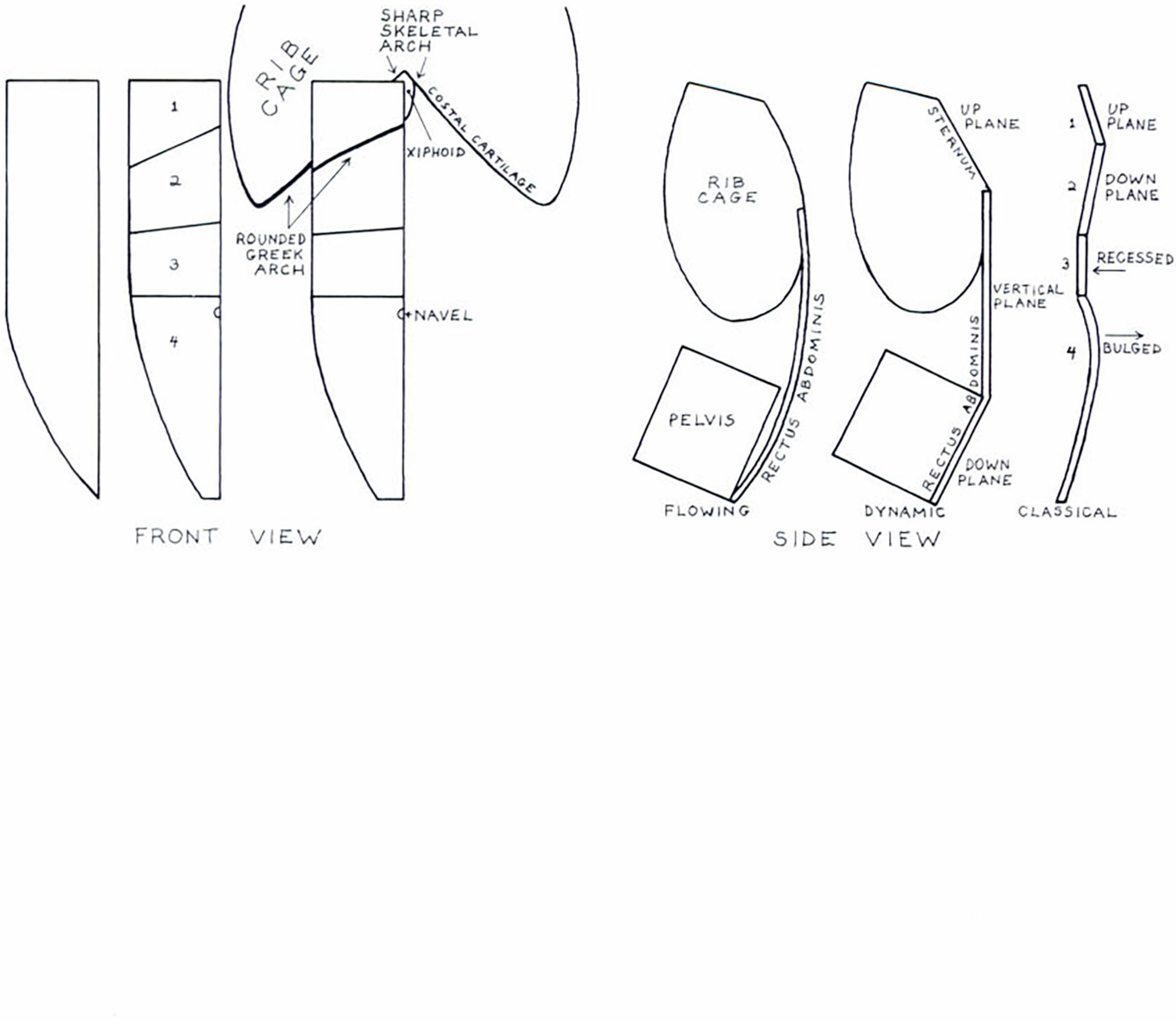
The two "arches" to look for at the front of the rib cage are the *rounded* Greek arch, produced by the rectus abdominis muscle and its uppermost tendinous intersection, or the *sharp* skeletal arch, produced by the costal cartilages meeting the bottom of the sternum just above the pit of the stomach. The sharp skeletal arch often predominates in the female, while the rounded Greek arch usually predominates in the male.

Faint **oblique ridges** on the surface of the rec-

tus abdominis, especially at its upper end, are occasionally created when the pectoralis major and external oblique contract and pull on the thin abdominal aponeurosis that covers the rectus abdominis. These ridges are in line with the direction of the fibers of the pectoralis and external oblique; the fibers of the rectus abdominis are vertical.

During forward trunk flexion, the muscle fibers shorten and the tendinous intersections move closer together. Two horizontal skin folds, seen at or above the level of the navel, separate the thoracic and pelvic masses. Laterally, these skin folds end at or just beyond the semilunar line, which remains visible.

When inhaling, the diaphragm pushes the abdominal contents downward, causing the rectus abdominis to protrude. When the trunk is flexed forward, the belly (and the rectus abdominis) bulges below the level of the navel.



External Oblique
(Obliquus Externus Abdominis)

ORIGIN External surfaces and inferior borders of the lower eight ribs (ribs five through twelve), on an anteriorly curved oblique line running downward and backward on the side of the rib cage.

INSERTION Anterior half to two-thirds of the outer lip of the crest of the ilium and the lateral edge of the anterior abdominal aponeurosis, which is its own wide, aponeurotic tendon of insertion. This tendon ultimately inserts into the linea alba, between the xiphoid process and symphysis pubis, where it meets the aponeurosis of the external oblique of the other side. The lowest fibers of the external oblique insert directly into the pelvis; the rest of the muscle inserts into its aponeurosis.

ACTION Bends the trunk laterally and rotates it (the side of the chest of the active muscle rotates forward); both sides working together flex the vertebral column, bringing the chest and pelvis toward each other. It also compresses the contents of the abdomen.

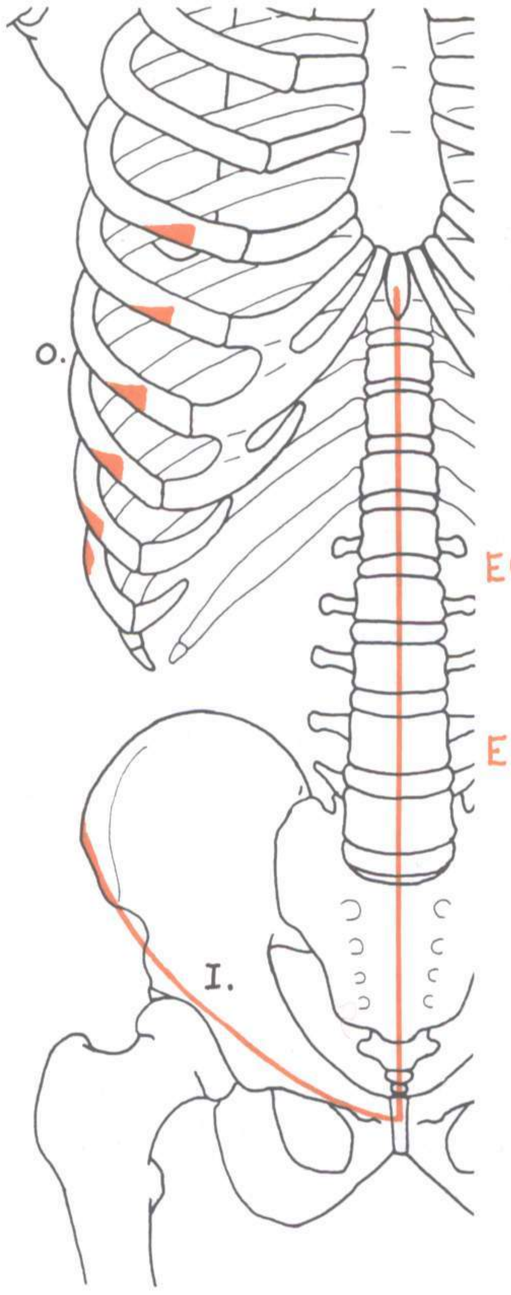
STRUCTURE The external oblique consists of a large, thin, muscular sheet on the side of the trunk and its large aponeurosis on the front of the abdomen. The muscular portion is divided into an upper **thoracic portion** and a lower **flank portion.** The aponeurosis lies *on* the surface of the rectus abdominis and is directly seen only at the linea alba, the semilunar line, and the tendinous triangular expansion at the bottom of the semilunar line (just above the inguinal ligament). The waist is located where the flank portion meets the thoracic portion, at the side of the rib cage near its bottom. A diagonal skin fold appears here when the thorax is laterally flexed toward this same side.

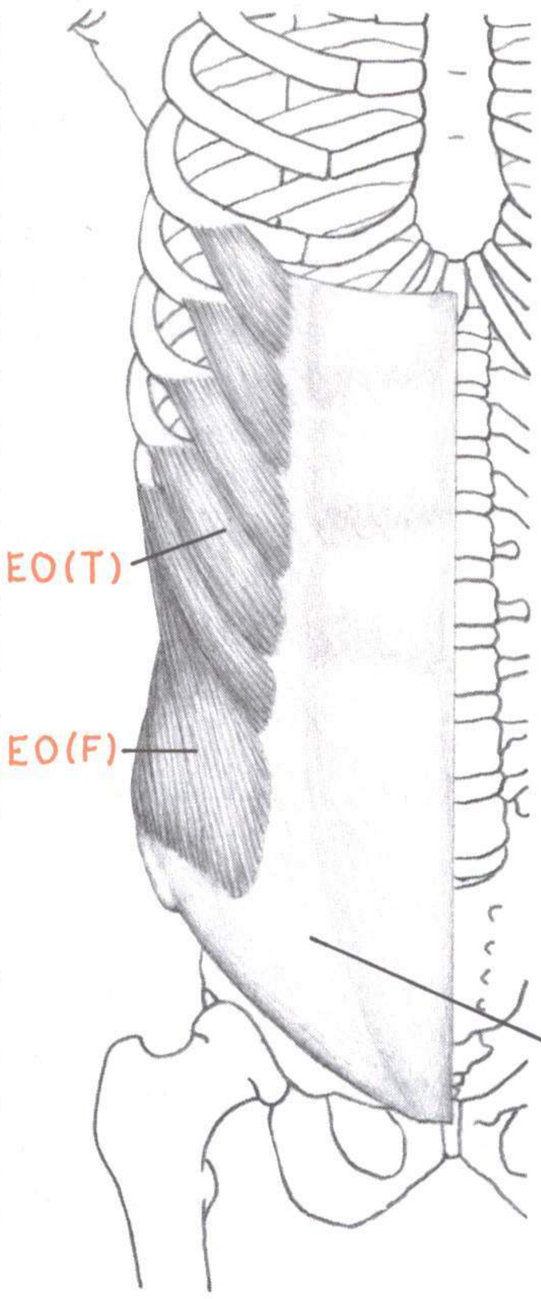
The **thoracic portion** closely adheres to the form of the rib cage. The individual ribs can be seen beneath it when the muscle is relaxed (especially when the rib cage is expanded during inhalation). When tensed, the thoracic portion becomes visible, dividing into elongated, oblique straplike bundles or digitations whose forms conceal the individual ribs yet lie on the overall rounded form of the rib cage. The difference between the external oblique bundles and the ribs, whose individual forms appear to be about the same size, is that the external oblique bundles are *straight* and almost parallel (they radiate very slightly from their line of origin), whereas the ribs *curve forward* at their costal cartilages. The forms of the external oblique bundles lie in the depressed intercostal spaces between the ribs. In general, the ribs are oriented slightly more toward the horizontal than are the muscle bundles, which are approximately 45° with the horizontal (especially the lower fibers). What ultimately appears on the surface is *either* the forms of the external oblique bundles (when tensed) or the individual ribs, not both simultaneously.

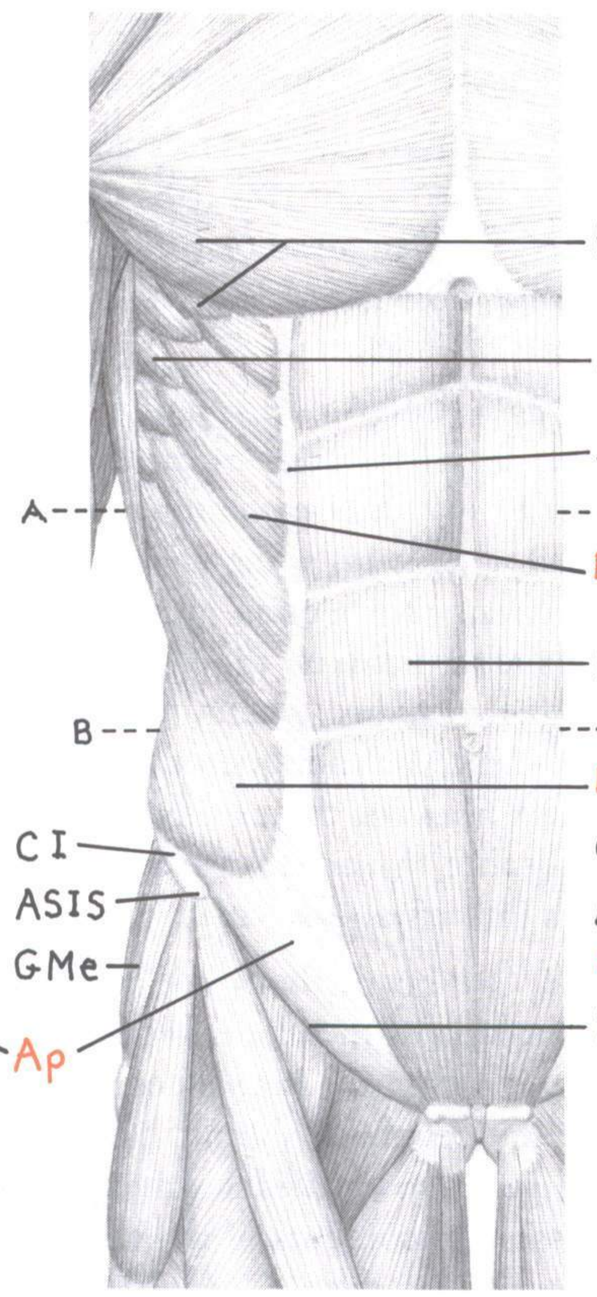
When tensed, the bundles of the thoracic portion can be seen interdigitating with the exposed lower bundles of the serratus anterior muscle on the side of the chest. The uppermost bundle of the external oblique originates below the first *visible* bundle of the serratus anterior. The serratus bundles radiate more (from the inferior angle of the scapula), bulge more, and generally are more horizontal than the external oblique bundles. The interdigitations between the inferior bundles of the external oblique and the thoracic slips of the latissimus dorsi are difficult to see. The anterior end of the lowest *thoracic* bundle of the external oblique may appear to be part of, yet distinct from, the top of the flank pad form. This is because the obliquity of this particular bundle brings its front end beyond the costal cartilages to the flank pad—posteriorly it is part of the thoracic portion, anteriorly it is part of the flank portion. This bundle is a transitional form between the two portions of the external oblique.

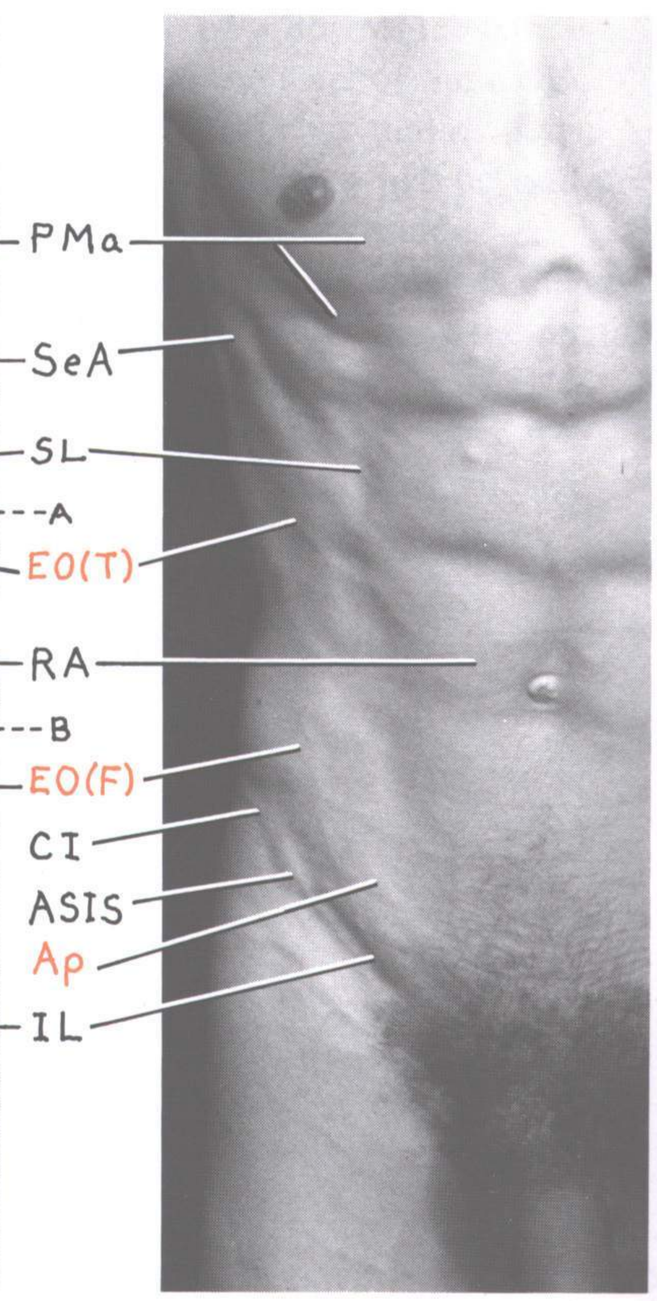
The lower half of the muscle fibers of the thoracic portion that originate from the last few ribs continue inferiorly as the **flank portion** of the external oblique. Along with the crescent-shaped fat pad at its lower back corner, it forms the **flank pad,** an elongated trapezoidal shape that curves around the side of the trunk, located between the rib cage and pelvis. This form is bordered above by the diagonal waist, below by the iliac line, in front by its own line of insertion of its muscular fibers into its aponeurosis, and behind by the line between itself and the erector spinae. The actual posterior free edge of the muscle is concealed by the fat pad. The form of the flank pad—taller in front and shorter in back—resembles a section of a cylinder as it curves around the side of the trunk. The flank pad is smooth—the fat pad blends into the form and its muscle fibers are usually not seen (the bundles of the thoracic portion, however, are usually seen when the whole muscle is tensed). In the front view of the body, the side profile of the flank pad is typically slightly convex, but it may be straight or have a subtle double convex curvature.

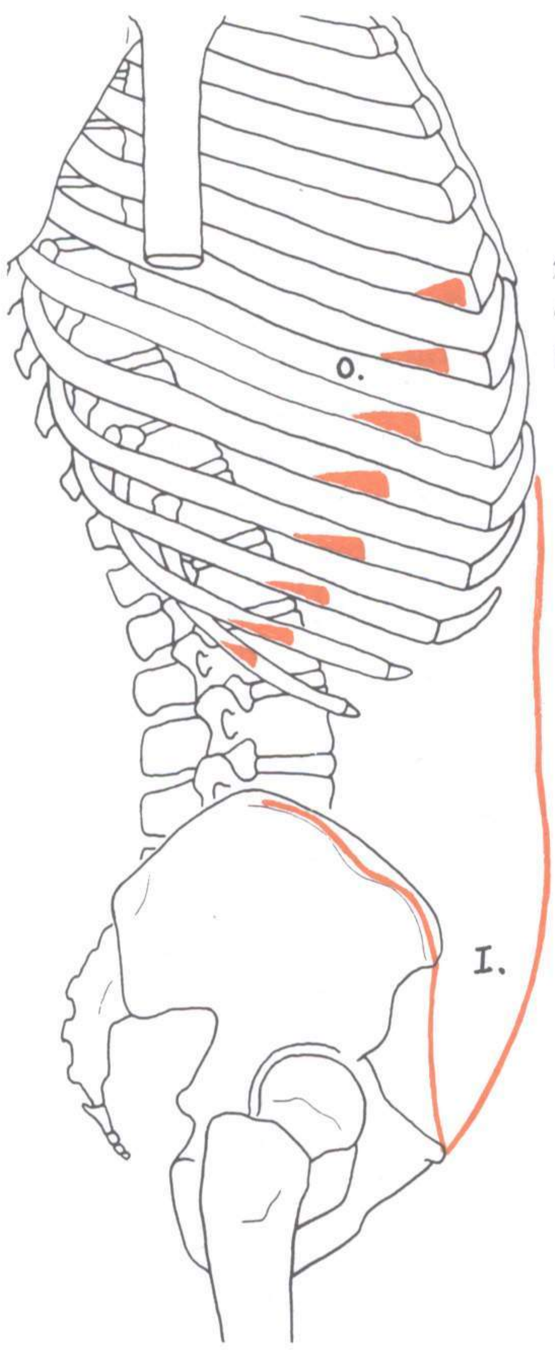
The *muscle fibers* of the external oblique never pass below the outer lip of the iliac crest (its insertion); however, the *flank pad* does, and the lower edge of the flank pad is called the **iliac line.** This almost straight, oblique line is directed forward and slightly downward, whereas the *iliac crest* of the pelvis—subcutaneous and visible anteriorly, deep to the flank

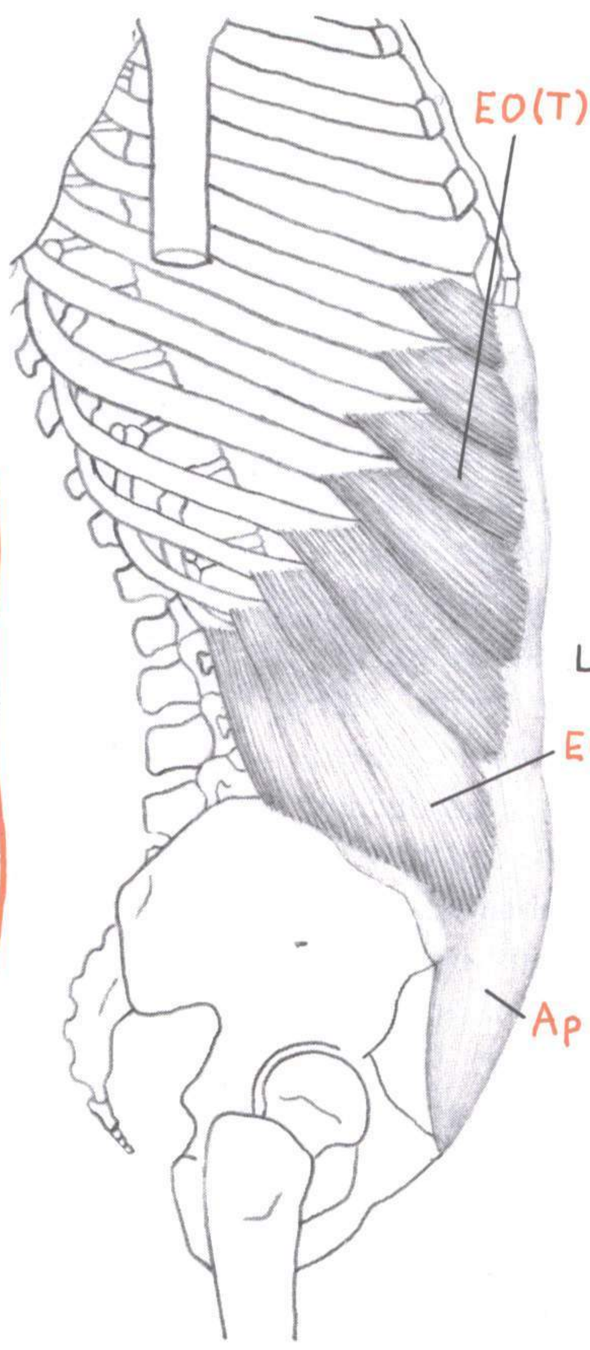


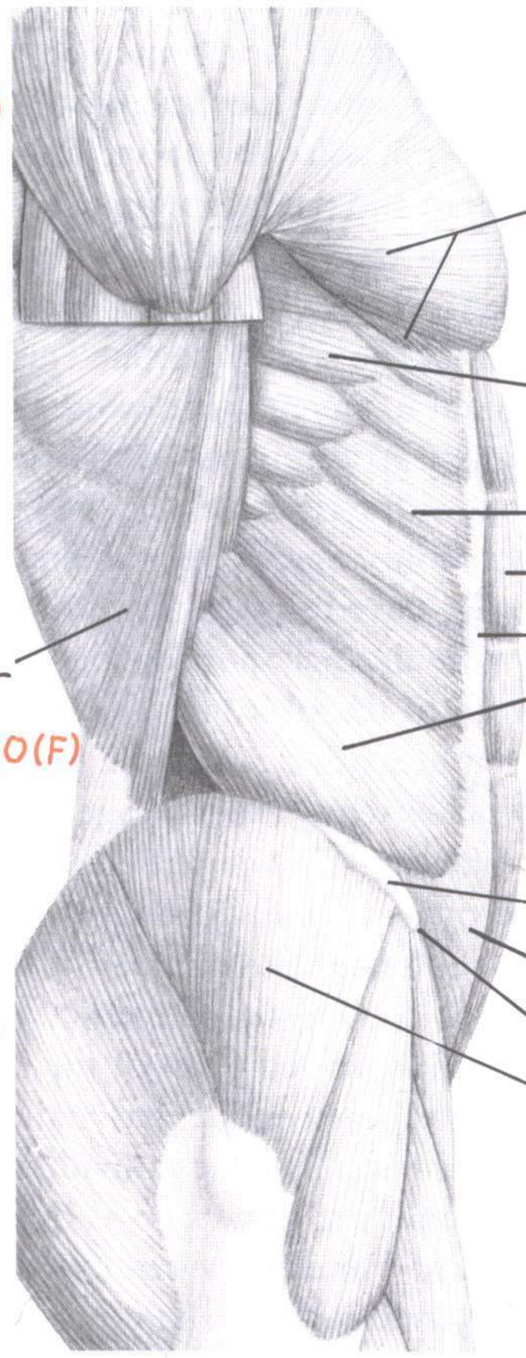


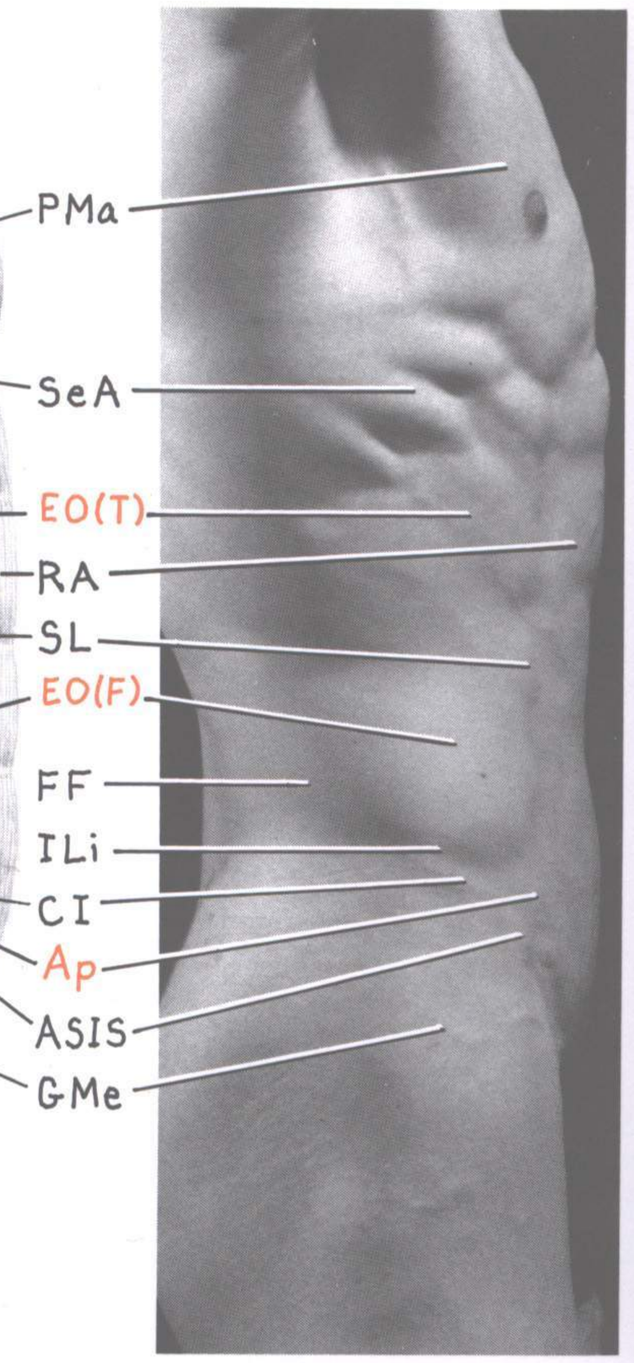




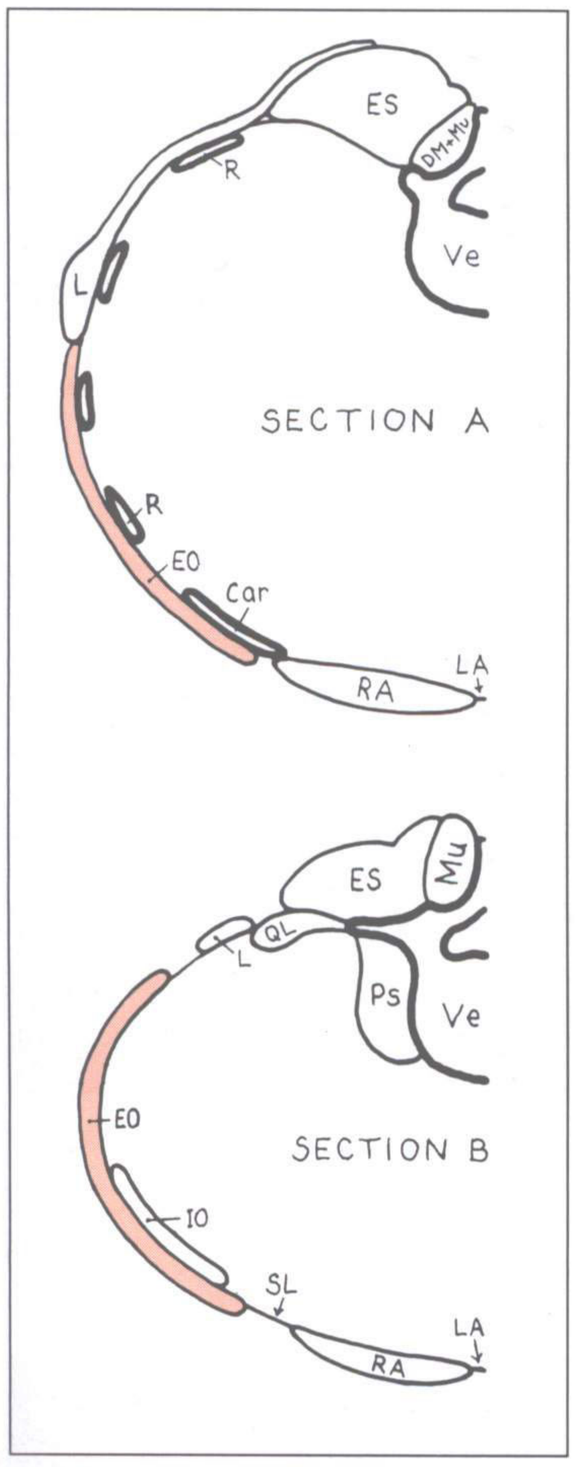








Ap *Aponeurosis* **ASIS** *Anterior superior iliac spine* **Car** *Cartilage* **CI** *Crest of ilium*
EO *External oblique* **EO(F)** *External oblique—flank portion* **EO(T)** *External oblique—thoracic portion*
FF *Flank fat pad* **GMe** *Gluteus medius* **IL** *Inguinal ligament* **ILi** *Iliac line* **IO** *Internal oblique*
L *Latissimus dorsi* **PMa** *Pectoralis major* **R** *Rib* **RA** *Rectus abdominis* **SeA** *Serratus anterior*
SL *Semilunar line*



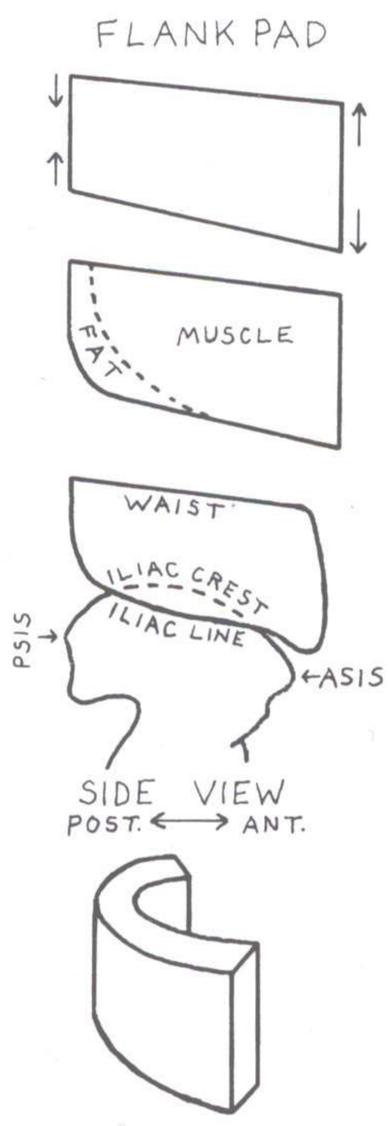
pad posteriorly—has a high curved arc. The iliac line has a subtle, elongated S curve. It intersects with the iliac crest at a point one-third of the way back on the crest (at the widest point of the pelvis). The actual overlap of the posterior portion of the flank pad, past the iliac crest and onto the surface of the gluteus medius, consists of fat and skin. The overlap increases when the thorax is bent laterally toward that side (the iliac line descends), as the extra skin accumulates. When bent to the other side, the iliac line and the overlap of the flank pad eventually completely disappear as they are stretched, which can expose almost the entire iliac crest. When the trunk is flexed forward, the posterior part of the iliac line disappears.

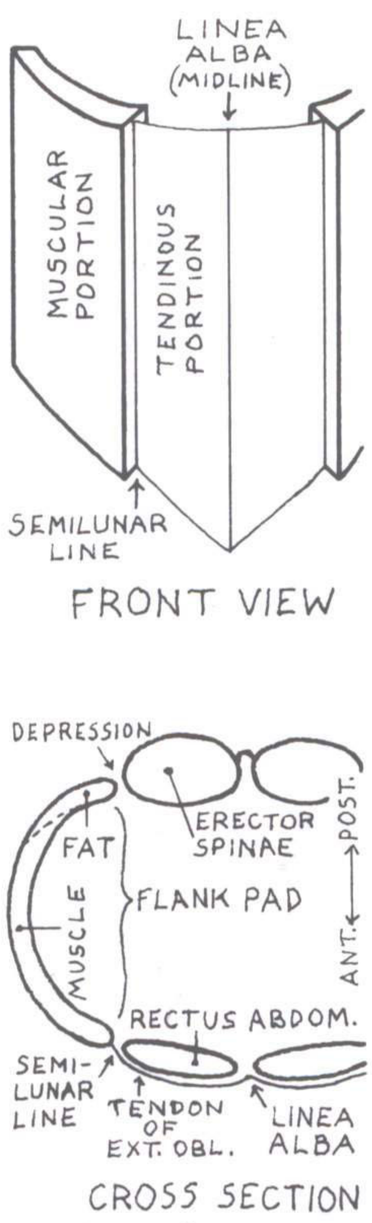
The **semilunar line** is the tendinous furrow located on the front of the abdomen between the rectus abdominis and external oblique. Inferiorly, at the level of the navel, it begins to expand into a triangular tendinous area whose surface bulges outward because of the abdominal contents deep to it. Part of the deep **internal oblique muscle** lies directly beneath this tendinous expansion, occasionally producing a narrow, oblique relief form beneath it, directed downward and medially (immediately above and parallel to the inguinal ligament).

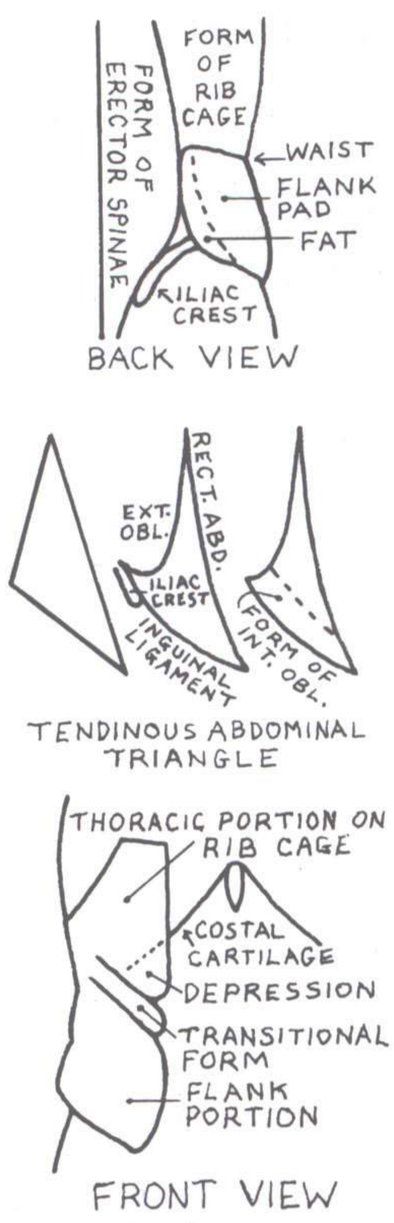
The muscle fibers of the external oblique that insert into its aponeurosis do so via separate bundles, which often creates a jagged, irregular line (the lateral edge of the rectus abdominis is smooth).

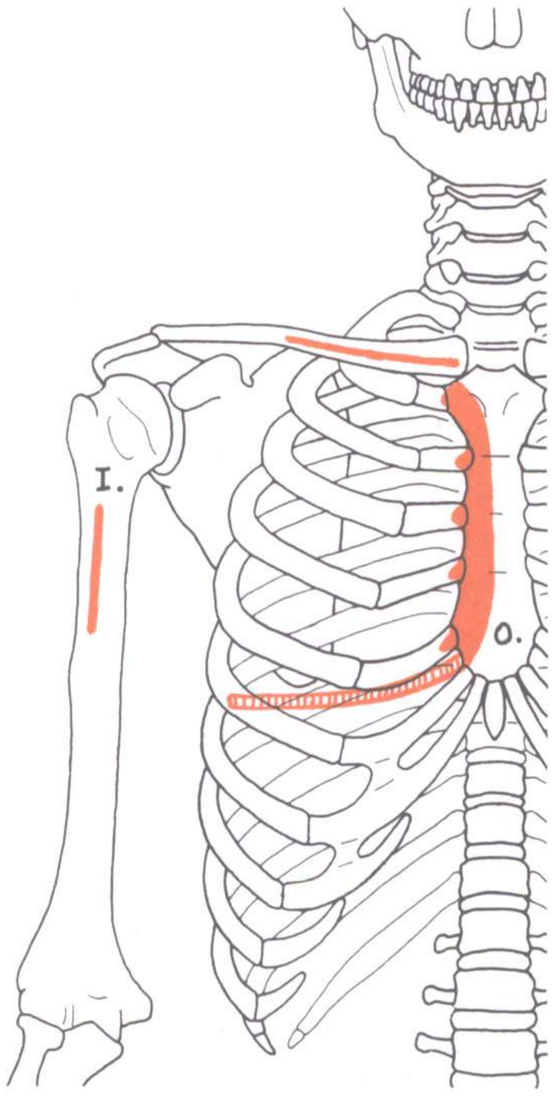
A triangular depression may occur in the portion of the external oblique belly immediately below the costal cartilage—just lateral to the semilunar line and just above the front portion of the flank pad. In this case, the costal cartilage becomes prominent.

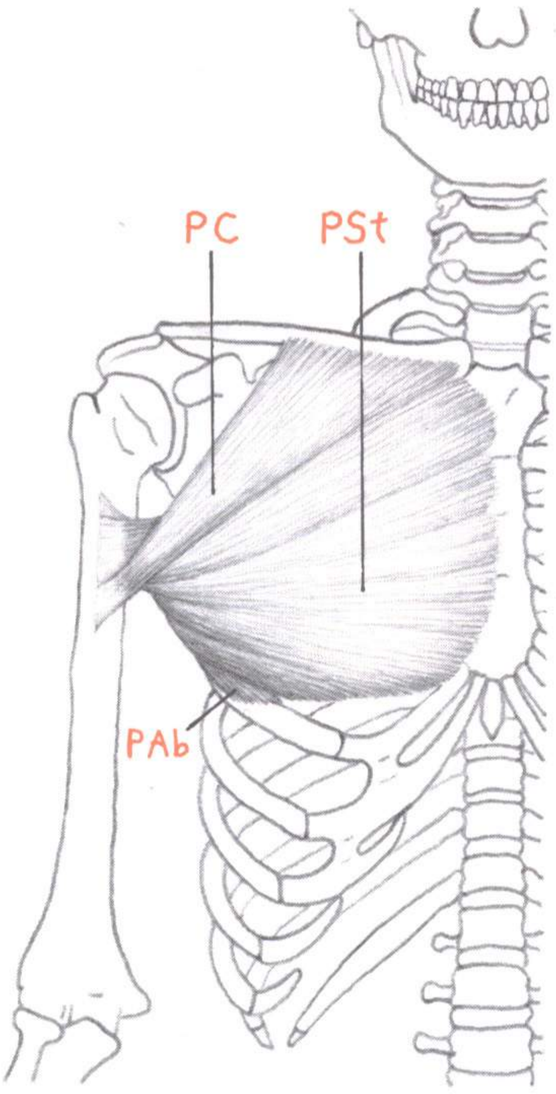
The **inguinal ligament** (Poupart's ligament) is the thickened lower border of the aponeurosis of the external oblique (it is not a separate structure). It is attached laterally to the *inside* of the anterior superior iliac spine and medially to the pubic tubercle, near the midline. It forms either a curved or straight line, marking the separation between the abdomen and thigh. It straightens and deepens when the thigh is flexed. When seen in the female (where it is usually very faint), the inguinal ligaments of both sides form a wider V than in the male. This is because in the female the level of the anterior superior iliac spines is closer to the level of the pubis, and the two anterior superior iliac spines are relatively farther apart (the female pelvis is shorter and wider than the male pelvis).

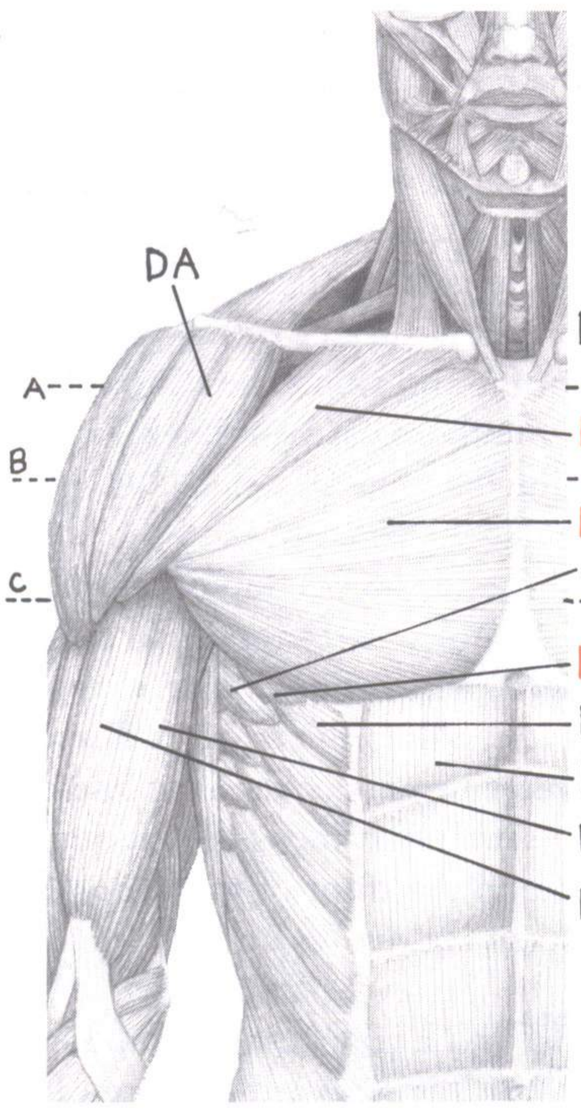


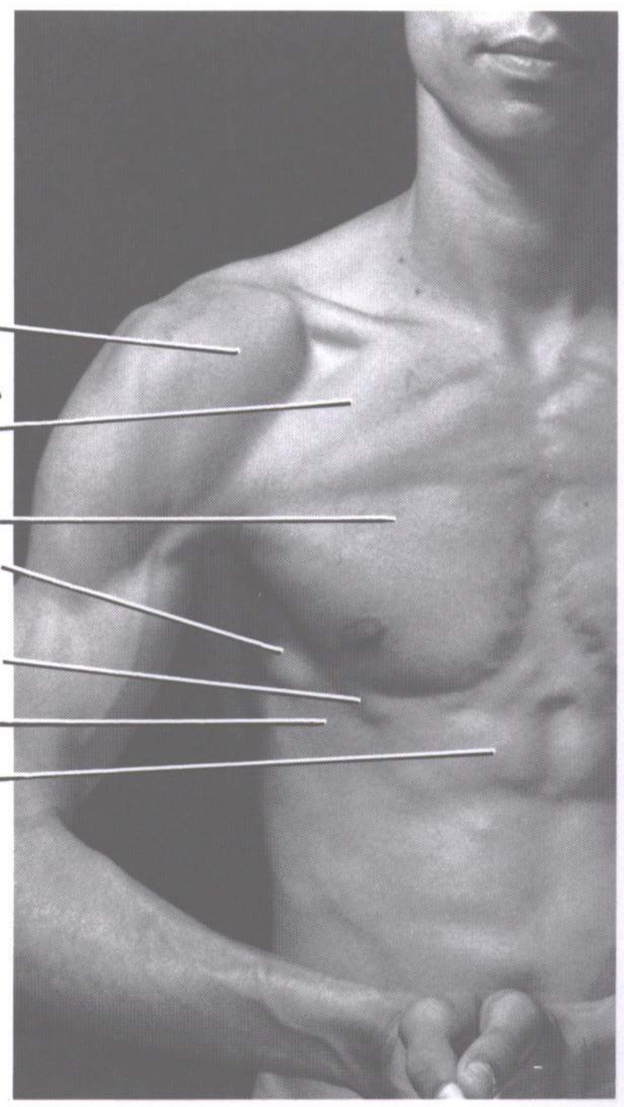


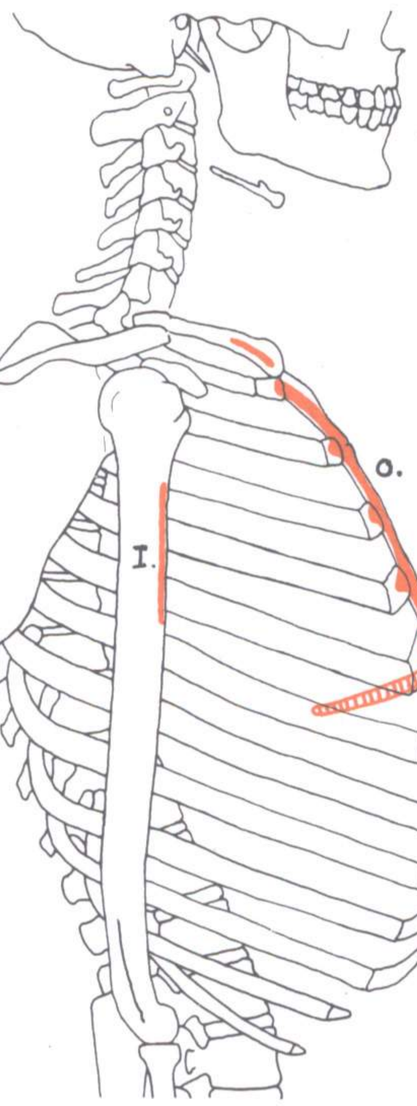


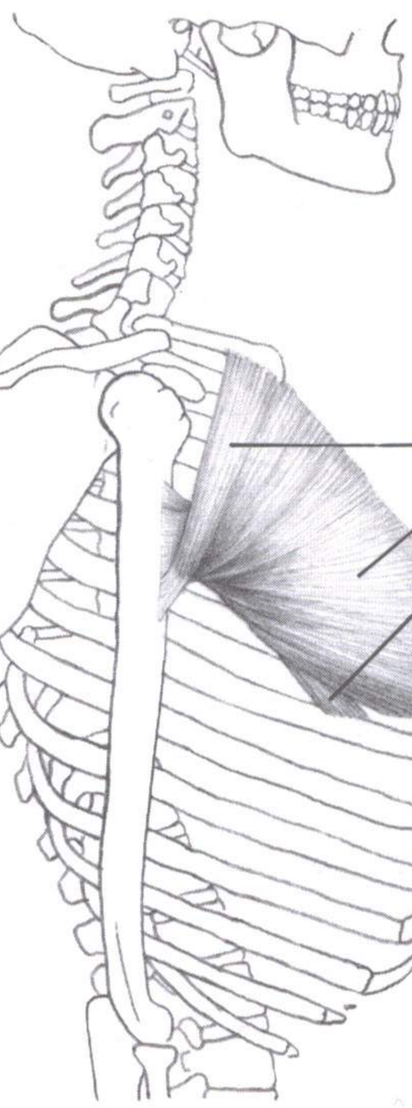


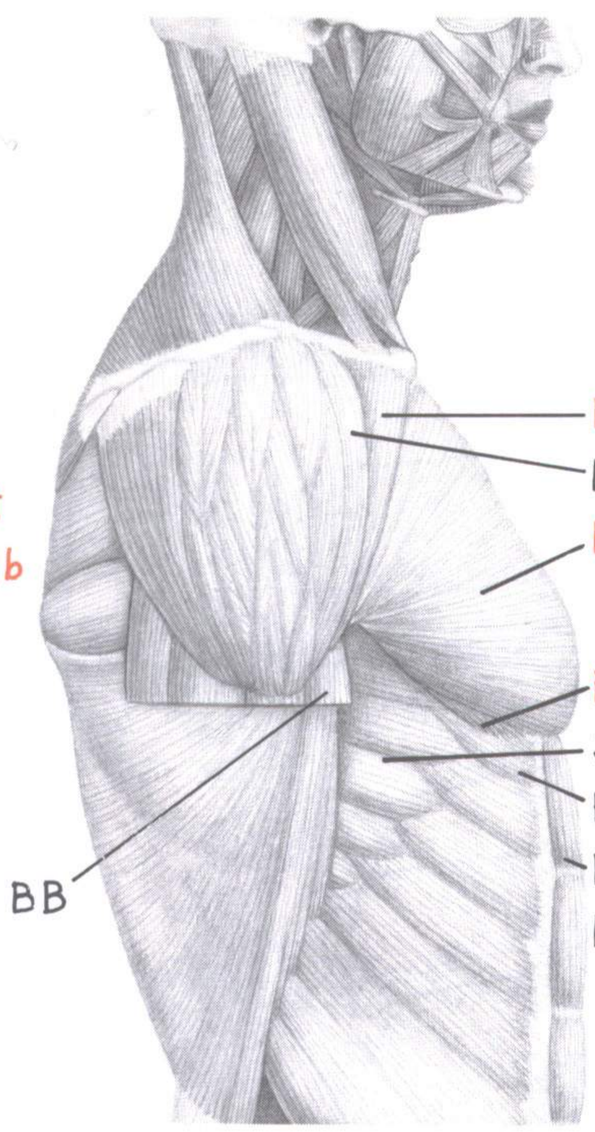


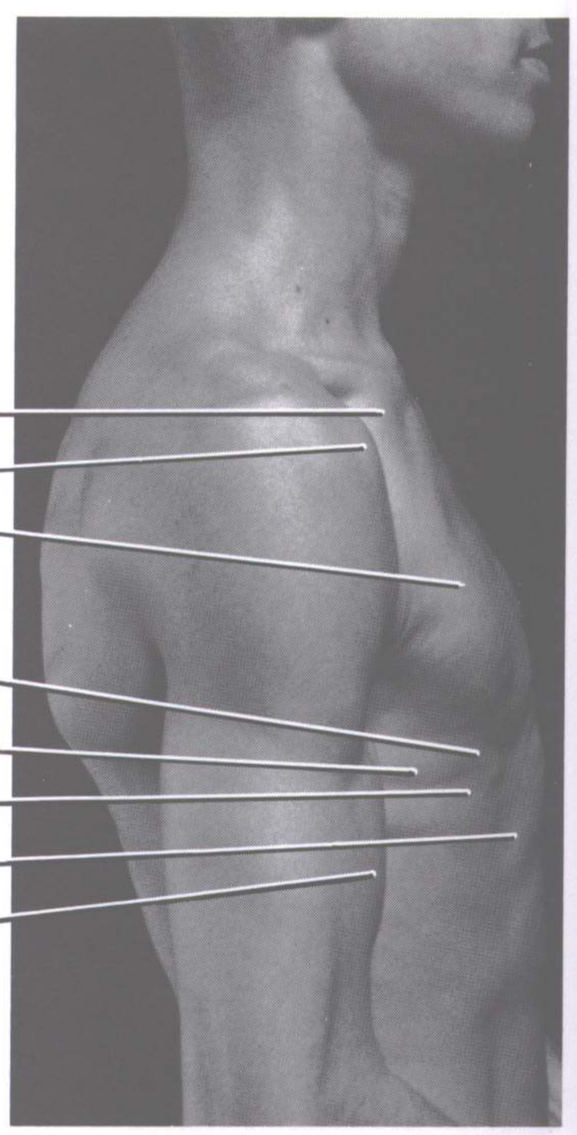




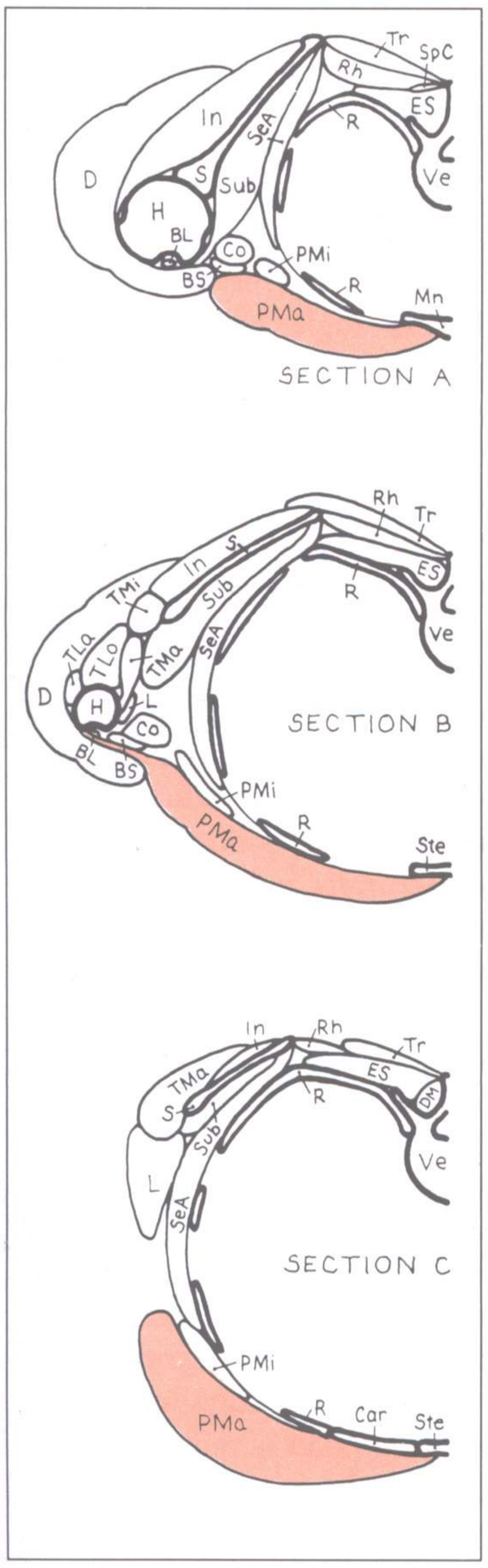








BB *Biceps brachii* **BL** *Biceps brachii—long head* **BS** *Biceps brachii—short head* **Car** *Cartilage*
D *Deltoid* **DA** *Deltoid—anterior portion* **EO** *External oblique* **H** *Humerus* **Mn** *Manubrium*
PAb *Pectoralis—abdominal portion* **PC** *Pectoralis—clavicular portion* **PMa** *Pectoralis major*
PMi *Pectoralis minor* **PSt** *Pectoralis—sternocostal portion* **R** *Rib* **RA** *Rectus abdominis*
SeA *Serratus anterior* **Ste** *Sternum*



Pectoralis Major

ORIGIN The anterior surface of the medial half of the clavicle, the entire length of the anterior surface of the sternum toward its lateral edge (not from the xiphoid process), the cartilages of the first six or seven ribs, and the upper end of the aponeurosis of the external oblique muscle (abdominal aponeurosis) lying on the top of the rectus abdominis muscle.

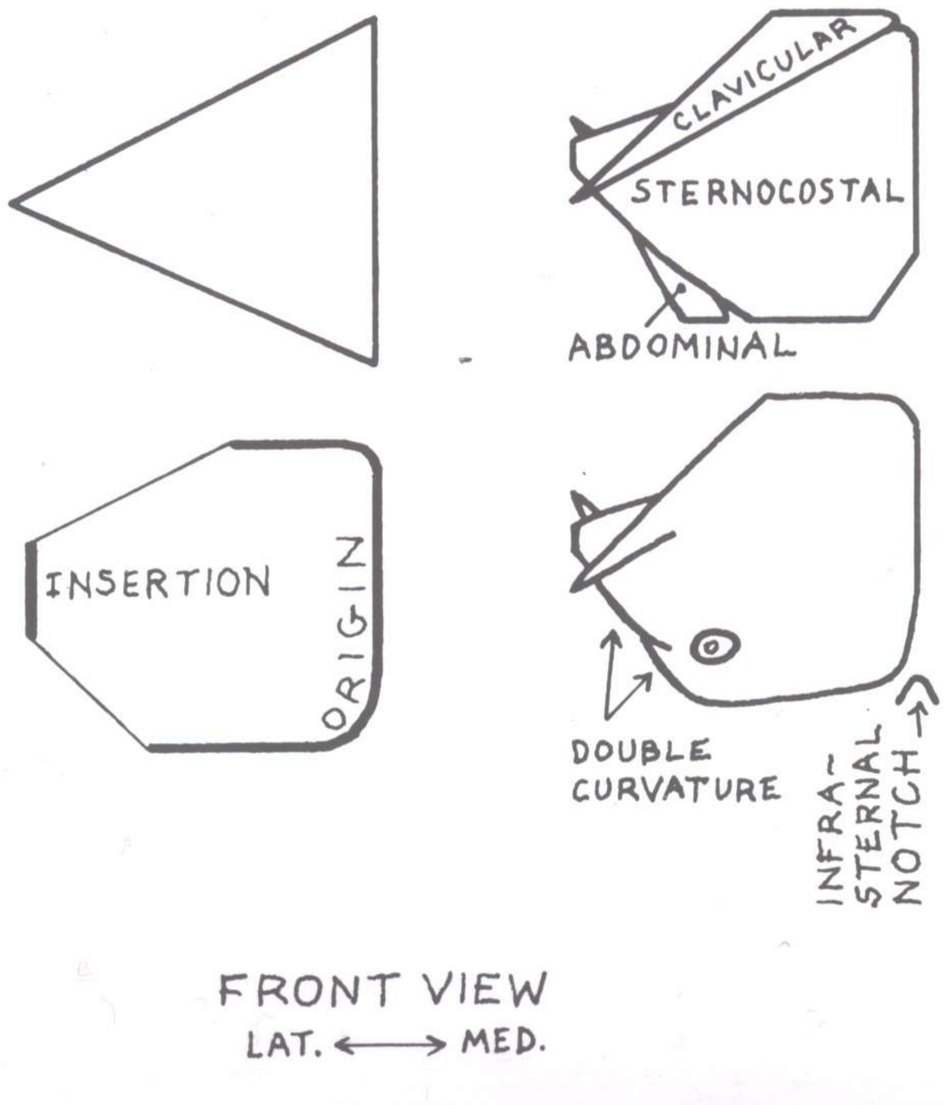
INSERTION Lateral lip of the intertubercular sulcus (bicipital groove) on the front of the humerus.

ACTION Adducts the arm, pulling it across the chest; medially rotates the arm. The clavicular portion will raise (flex) the arm, while the lower lateral sternocostal portion will then pull it down (extend it, but not hyperextend it, back past the rib cage).

STRUCTURE The pectoralis major is a large, thick, fan-shaped muscle lying on the front of the thorax. It crosses the front of the armpit, where it remains thick, and then attaches to its thin, square tendon of insertion, which enables it to pass under the deltoid to its insertion. No muscular fibers of the pectoralis pass under the deltoid—only its tendon does.

The pectoralis is divided into **clavicular** and **sternocostal portions,** based on the origin of these sections. The most lateral and inferior division of the sternocostal portion is called the **abdominal portion.** Classically, the pectoralis major is flat, planar, and squared-off, but it can also be rounded and bulging, depending on its variable outline and the development of its muscular mass. The pectoralis major forms the thick muscular anterior wall of the armpit. The deep and unseen **pectoralis minor** lies behind it, adding thickness to the medial end of the wall of the armpit. A small part of the pectoralis minor may actually come to the surface between the pectoralis major and the uppermost visible digitation of the serratus anterior, but it is not defined or seen as a distinct form.

As they come off their origin, the muscle fibers of the pectoralis major divide into numerous bundles. The bundles taper and converge laterally, progressively overlying one another, a superior bundle crossing in front of the bundle immediately inferior to it. These bundles become quite conspicuous when the muscle is contracted. The uppermost clavicular fibers are directed downward and laterally toward the bottom of the line of insertion; the lowest and most lateral abdominal fibers from the side of the chest are directed upward and laterally toward the top of the line of insertion; and the remaining large group of bundles between them are, as a group, directed across toward the middle of that line. This arrangement creates a thick, muscular, **crisscross twisting** of the fibers in front of the armpit, with the clavicular portion on top (in front) and the abdominal portion deep in back. All these fibers attach into a square common tendon which then passes through the narrow space under the deltoid and over the biceps to reach its insertion on the humerus. Several vertical skin wrinkles appear in life on top of the crisscrossing fibers when



the arm is down. They radiate from below upward and are each perpendicular to the muscle fiber bundles they cross. The crisscrossing of the fibers disappears as the arm is raised upward.

The narrow, elongated, triangular **clavicular portion,** passing outward and downward, is at first separated from the deltoid by a small triangular depression below the clavicle, the **infraclavicular fossa** (deltopectoral triangle). The separation is continued downward as a groove between the two muscles as they travel side by side, with the cephalic vein lodged between them.

On the chest, the clavicular portion is part of (on the same plane as) the form of the rest of the pectoralis; its distal end, at its insertion, however, separates from the sternocostal portion and is more closely associated with the form of the deltoid.

The **sternocostal portion** is by far the largest portion of the muscle. In individuals with slight muscular development, it is thin, and the articulations between the ribs and their costal cartilages, and sometimes the articulations between the costal cartilages and the sternum, can be seen through the thin muscle layer. As it originates off the sternum, the sternocostal portion gets progressively thicker and more muscular inferiorly. The upper half shows its separate horizontal bundles or the underlying ribs and cartilages, whereas the lower half is usually thicker and smooth. At the upper part of the sternal origin, the muscles of both sides of the body either touch each other on the midline or are separated by a small interval. The lower end of the line of origin from the sternum veers laterally. This divergence of the origins of the muscles of both sides exposes a triangular subcutaneous area on the lower end of the sternum.

The **lower border** of the pectoralis is either straight or curved and either horizontal or directed slightly downward and outward. It lies approximately at the level of the cartilage of the fifth rib, just below the level of the top of the epigastric depression (infrasternal notch). It is more pronounced laterally (the muscle is thicker laterally). When the arm is fully raised, the lower border disappears, and the lower portion of the pectoralis major thins out and flows into the form of the rib cage. The ribs underneath this portion (attaching to the lower half of the sternum) may now begin to show.

Laterally, the edge of the pectoralis ascends toward the front of the arm. This rounded **lateral border** may have a single curvature or classically develop a double curvature when the arm is abducted slightly. The double curve is created when the sternocostal portion separates from the abdominal portion, as the abdominal portion passes deep to the sternocostal portion (the abdominal portion heads toward the top of the line of insertion on the humerus, the sternocostal portion heads toward the middle of the line). The form of the lateral end of the clavicular portion remains part of the deltoid and does not participate in this double curvature. (The pectoral fat pad in the male lies on the abdominal portion of the pectoralis and helps create the lower convexity of the double curvature.)

The small, lateral **abdominal portion** shows a great deal of variation in terms of how distinct it is from the rest of the muscle and how far it extends downward past the lower border of the pectoralis onto the front surface of the rib cage toward the rectus abdominis.

When the horizontal arm is thrust forward in front of the body, the pectoralis broadly bends upon itself, becoming infolded, hollowed, or furrowed *vertically* in front of the armpit—the large medial half of the muscle stays against the rib cage, while the lateral half is pulled away from it; the muscle belly becomes divided into two planes that meet at a line drawn from the middle of the clavicle to the nipple.

In the male, the crescent-shaped **pectoral fat pad,** of variable size, sits on the lower outer corner of the muscle. It helps square the lower outer corner of the muscle. The nipple lies on the front surface of the muscle in this area, usually slightly above the level of the bottom of the body of the sternum and approximately half a head-length from the midline of the body. The female breast covers the lower half of the pectoralis and overlaps its lower border.

Latissimus Dorsi

ORIGIN A continuous line along the spinous processes and intervening supraspinal ligament of the lower six thoracic vertebrae, all the lumbar and sacral vertebrae, and the posterior third of the crest of the ilium; and by separate slips from the lower three or four ribs on the side of the thorax.

INSERTION A short vertical line at the bottom of the bicipital groove on the front of the humerus. The insertion onto the humerus is higher (more proximal) than the insertions of the teres major and pectoralis major.

ACTION Adducts, extends, and medially rotates the humerus. When the hands are free, it pulls the arm down and back (as in swimming), and when the hands are fixed, it lifts the body (as in climbing). Because it crosses the shoulder on its way from the trunk to the arm, it can depress or rotate the scapula (pulling the acromial end downward) when the scapula is not fixed in place by other muscles.

STRUCTURE The latissimus dorsi is a large, wide, sheetlike triangular muscle, uneven in thickness, located on the lower half of the back. It begins as a wide aponeurosis on the lower back and ends in a small square tendon deep in the armpit between the teres major and the coracobrachialis muscles.

The fleshy fibers of the latissimus attach to its wide tendon of origin in the curved or straight **line of attachment of the muscle fibers.** The muscle fibers attach into this line as numerous distinct bundles, making the line slightly irregular. This line of attachment of the fibers is seen infrequently, and only when the latissimus is tensed. It lies on top of the lateral form of the erector spinae.

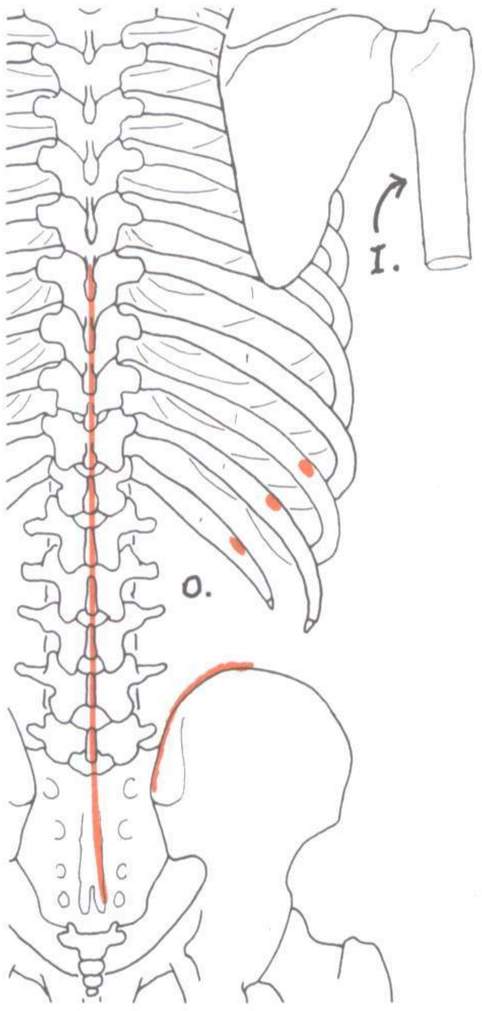
The **lateral border** of the latissimus begins fleshy at, or sometimes slightly above, the crest of the pelvis (lateral to the form of the erector spinae), picks up muscular slips originating from the lower three or four ribs, ascends on the side of the rib cage, and ends at its insertion on the humerus. What usually appears on the surface when the muscle is tensed, however, is a long, straight, straplike bulge passing upward and forward from the pelvis to the armpit. This form usually disappears inferiorly as it passes deep to the fat of the flank pad (its origin from the crest of the pelvis is concealed).

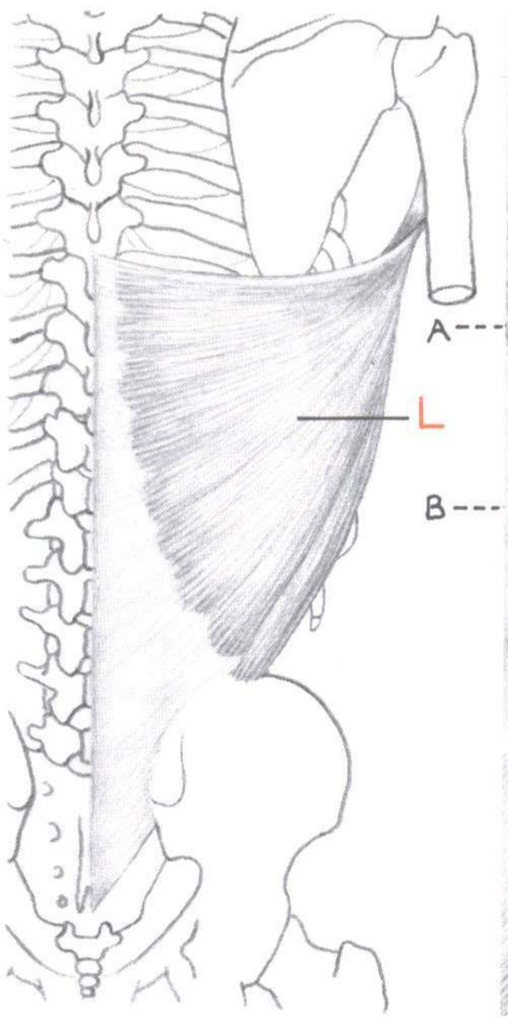
This straplike form does not include the muscular slips of the latissimus that originate from the ribs, which usually lie inconspicuously on top of the pronounced digitations of the serratus anterior. The latissimus rib slips do occasionally show, and when they do, they either blend with the longer straplike bulge or form an independent narrow form that is shorter, anterior to, and parallel to the main bulge. This independent narrow form lies on top of the serratus digitations and leaves only their anterior tips visible. The latissimus rib slips interdigitate with the fibers of the external oblique, but these interdigitations are usually difficult to see. The entire lateral border of the latissimus may therefore have a slight S-shaped curve—the upper portion curves forward superiorly because of the added anterior projection of the latissimus rib slips. When the shoulder is thrust forward, the upper end of the lateral border slides forward on the surface of the serratus anterior.

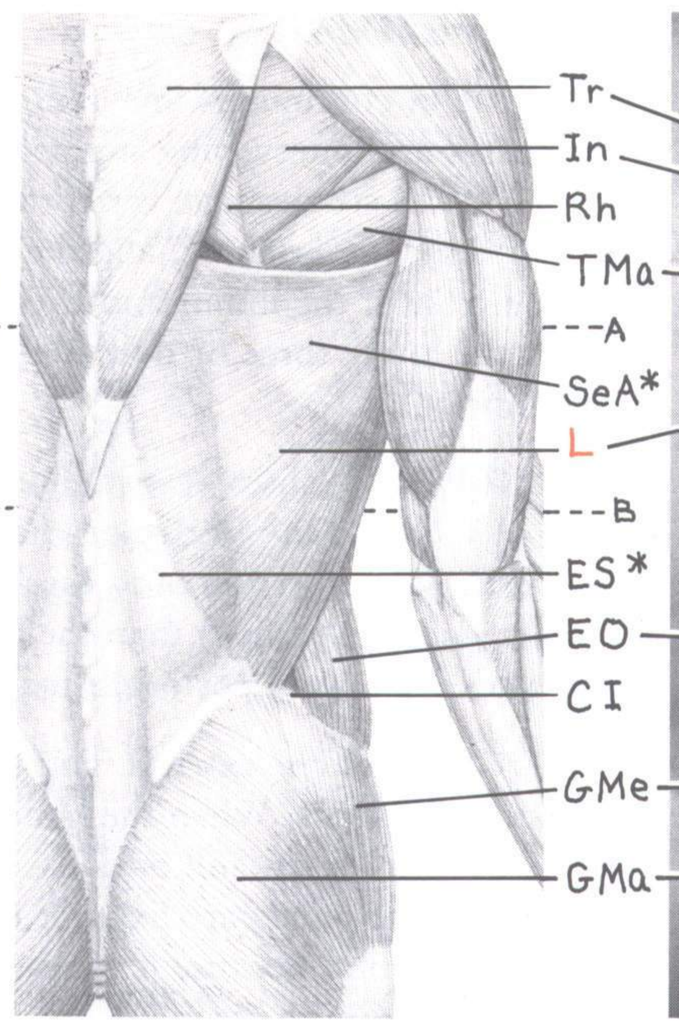
The **superior border** of the latissimus dorsi becomes superficial after it passes laterally from under the trapezius and then continues onward over the surface of the inferior angle of the scapula, from which new fibers may originate. The covering of the inferior angle of the scapula is the key to finding the level of the superior border of the latissimus. The superior border then heads across the belly of the teres major, passing beneath the lower edge as it heads laterally toward its insertion. Relating it to the front of the body, the superior border sits at or above the level of the lower border of the pectoralis major. It appears as the thickened edge of the blanketlike relief of the entire latissimus, which lies on, but does not conceal, the forms of the deeper structures beneath it.

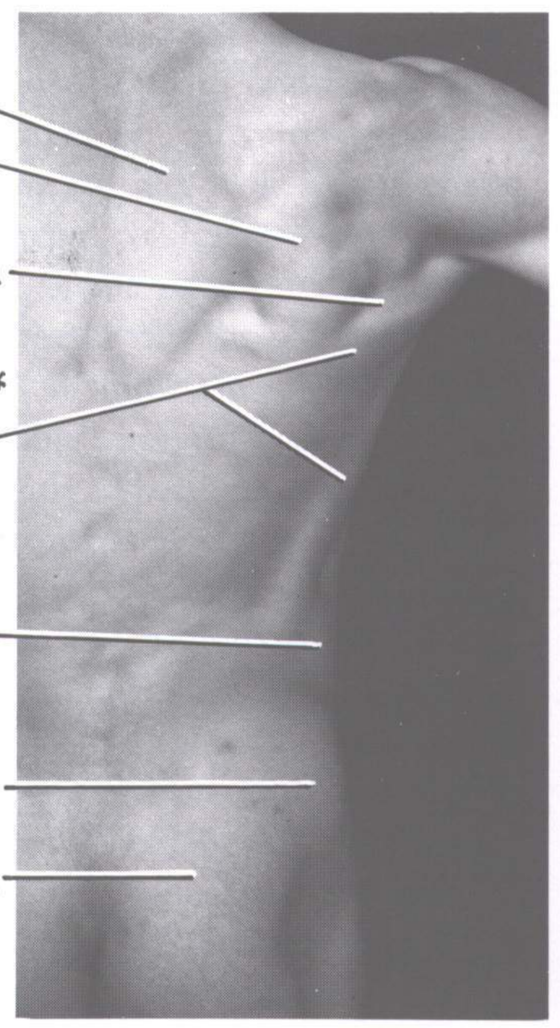
Laterally, the muscle twists, creating a sling under the cylindrical form of the teres major, so that the surface of the latissimus that was facing posteriorly is now facing anteriorly. As it heads laterally, the superior edge of the latissimus passes below and then in front of the teres major. Together these two muscles form the posterior wall of the armpit, whose edge exhibits a double convex curvature—the latissimus curve is located inferiorly and medially, and the teres major curve is located superiorly and laterally (the double curve is best seen when the arm is held horizontally out to the side of the body). This is caused by the different insertions of the two muscles onto the humerus—after the latissimus wraps around the teres, it inserts higher (or proximal) on the humerus, exposing the lateral half of the teres major, which inserts lower (or distal). As the arm is raised horizontally to the side, the latissimus dorsi (and the teres major) can be seen from the front view, because the posterior wall of the armpit is larger than the anterior wall (formed by the pectoralis major).

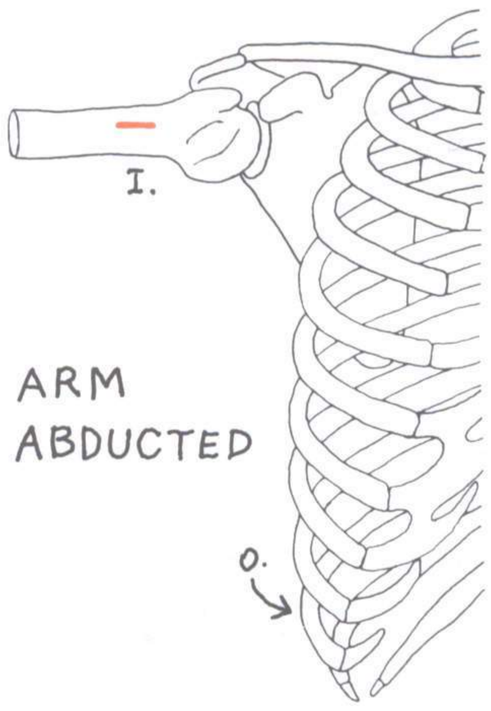
For the most part, the latissimus dorsi is thin, and the forms seen on the surface are the forms of the underlying structures—the erector spinae,

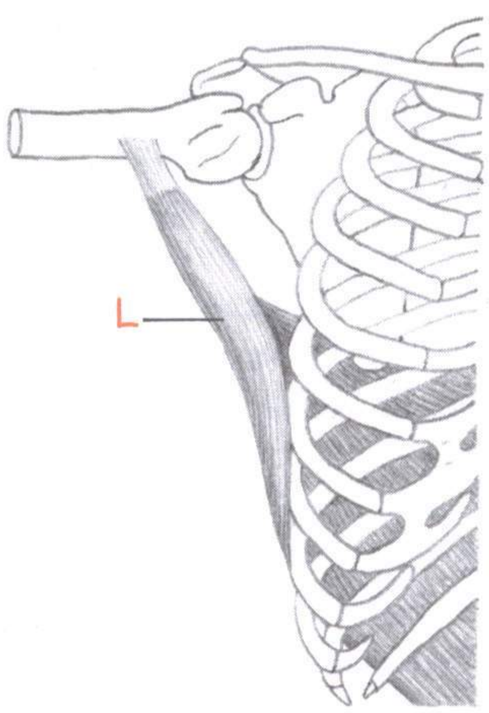


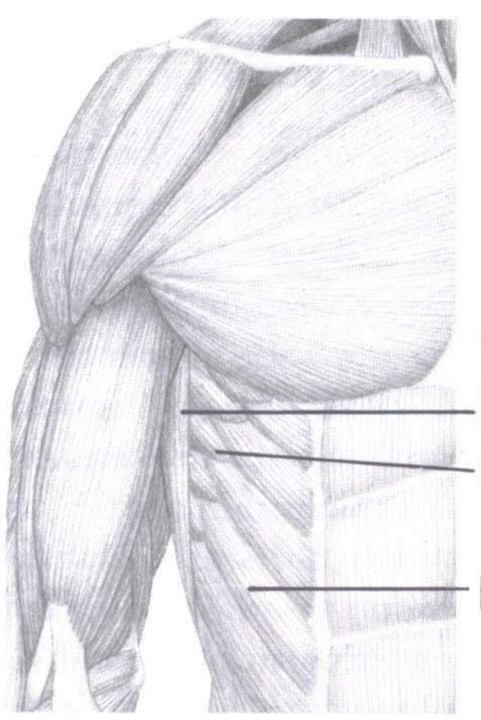


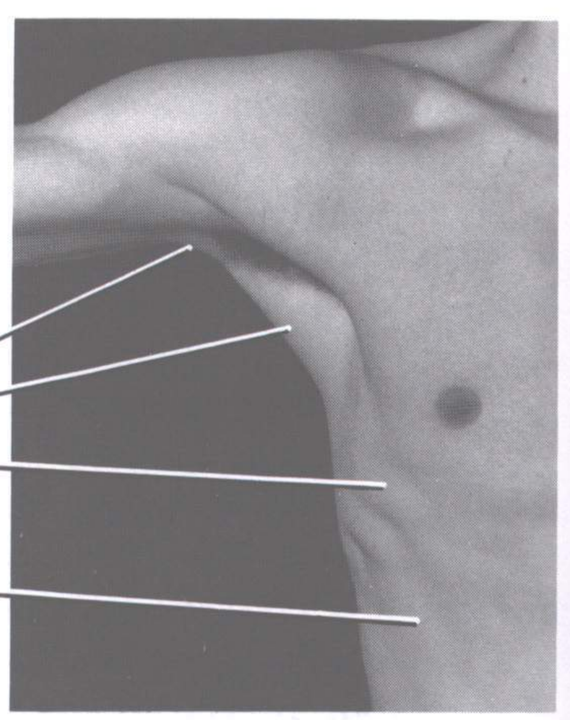


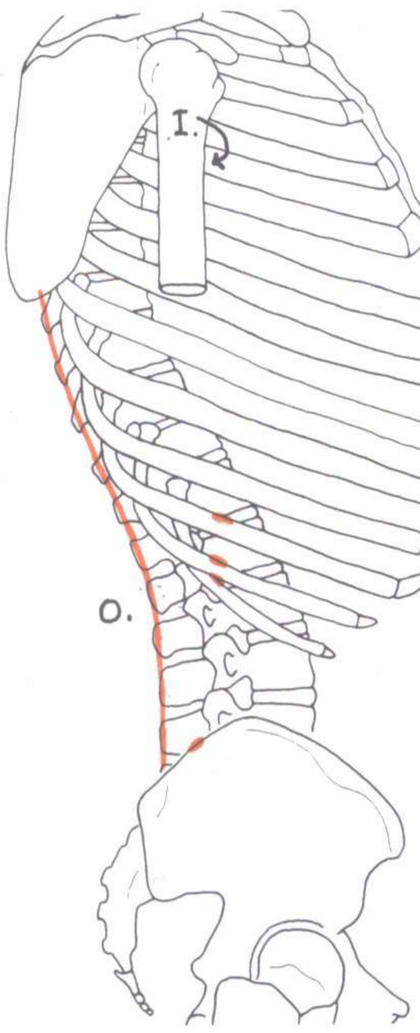


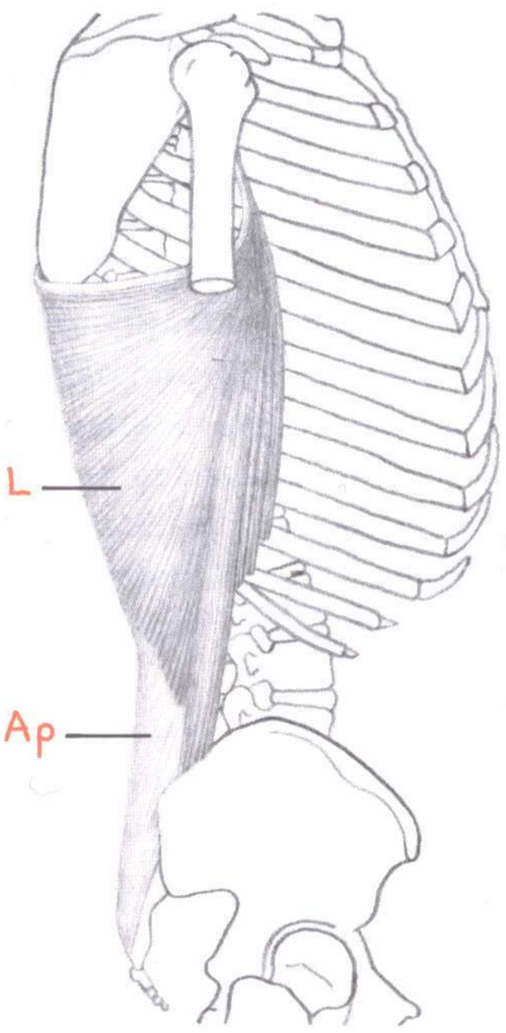


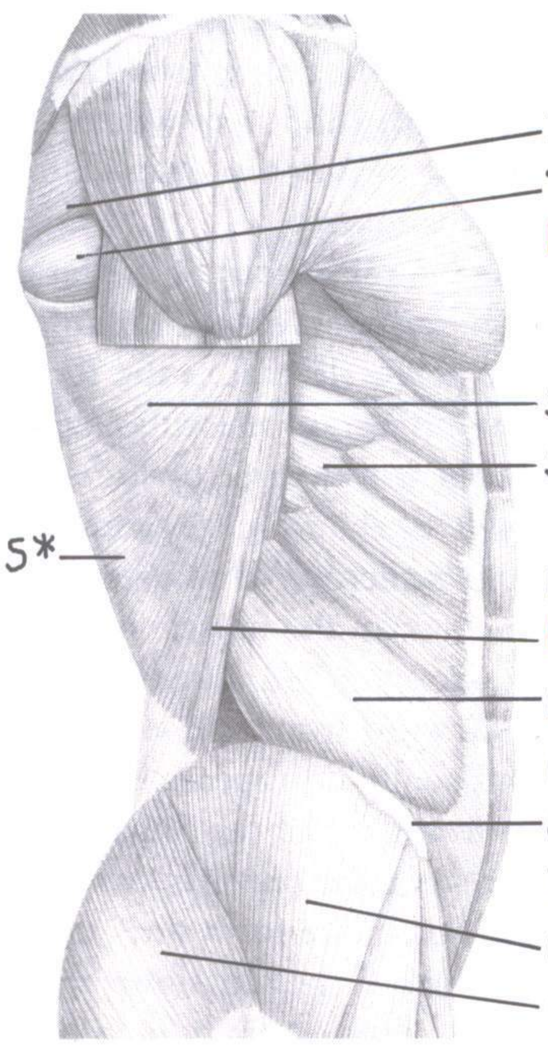


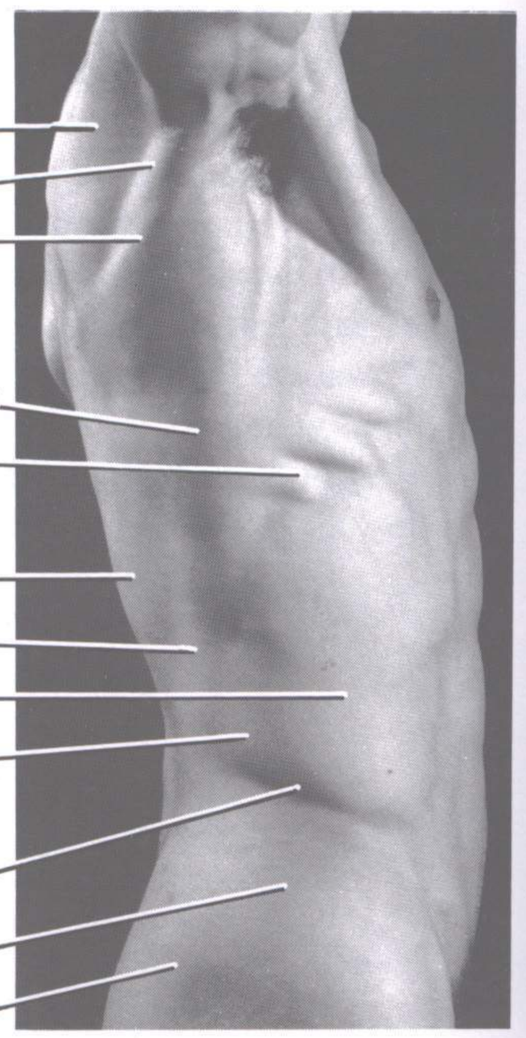




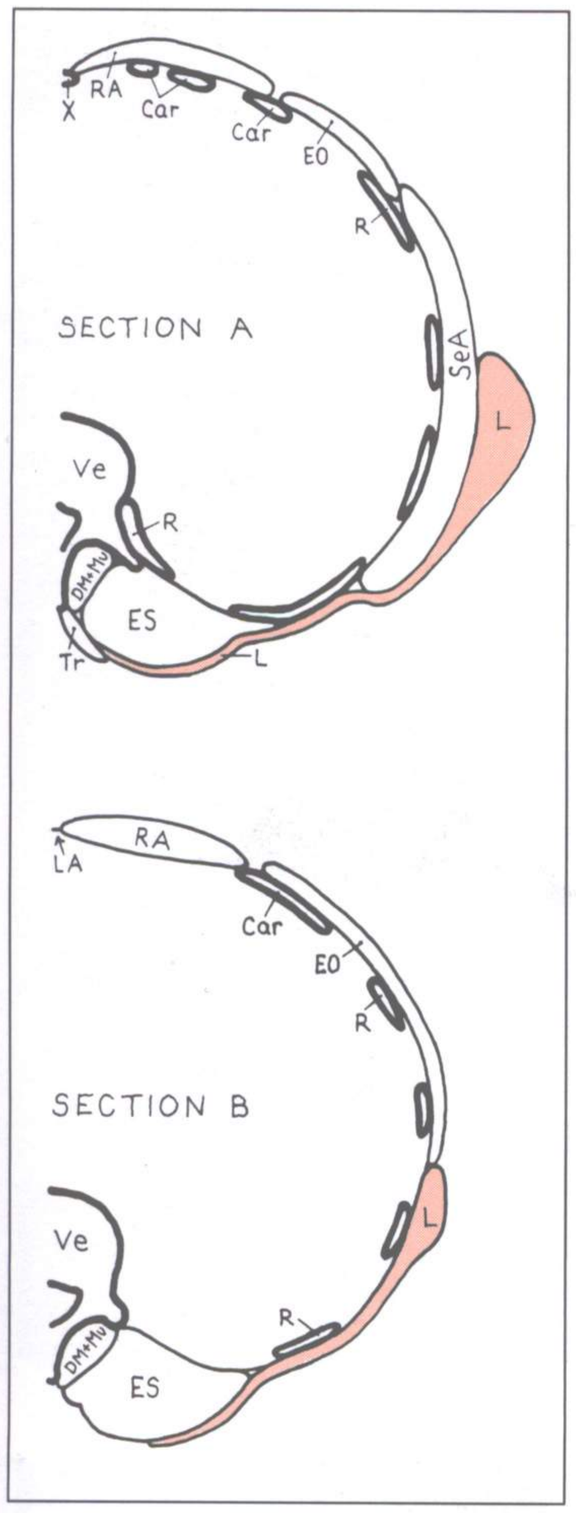




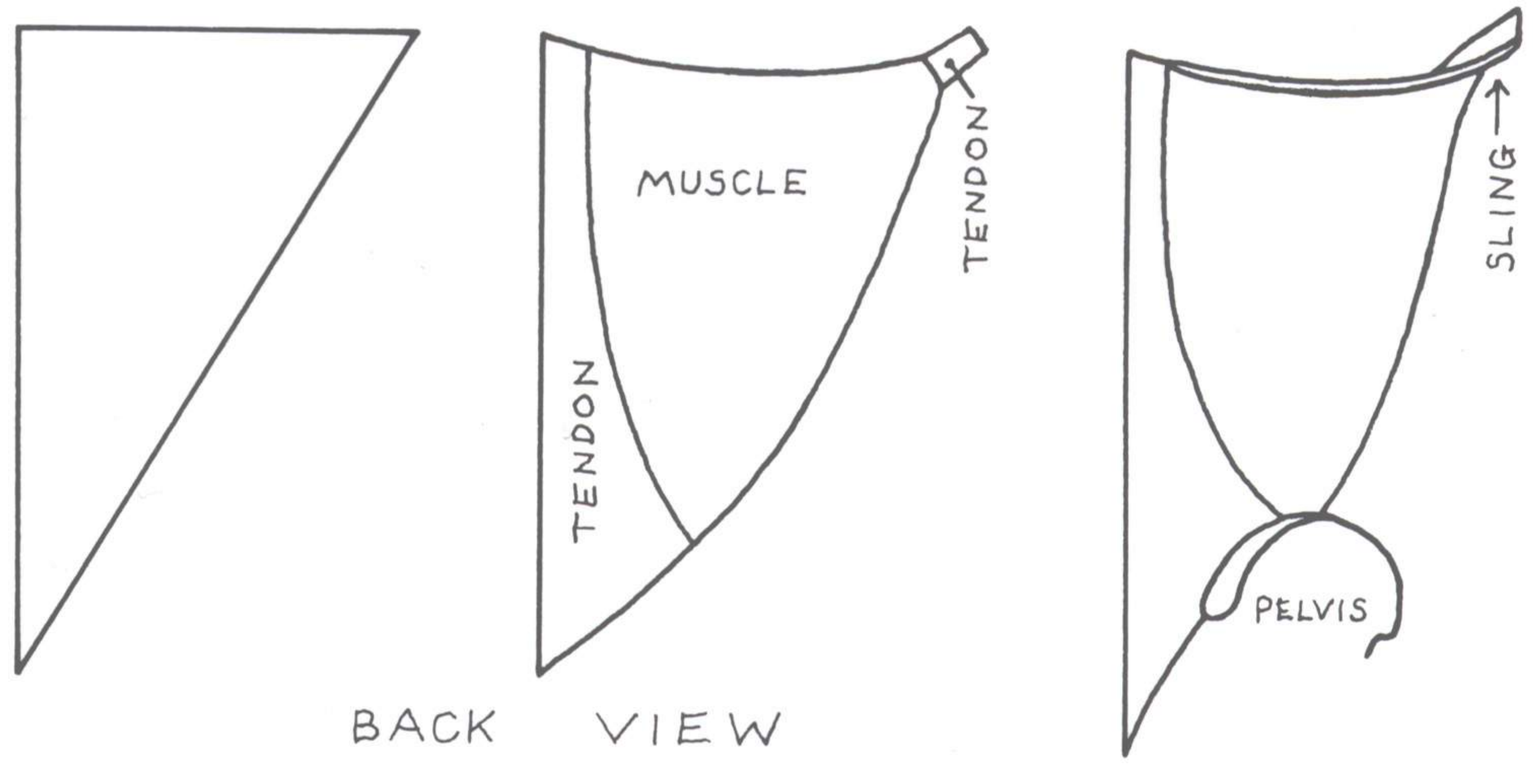


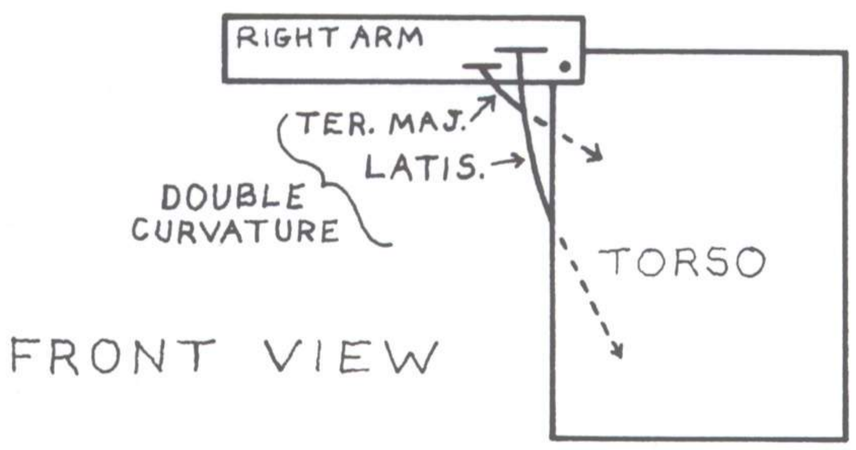


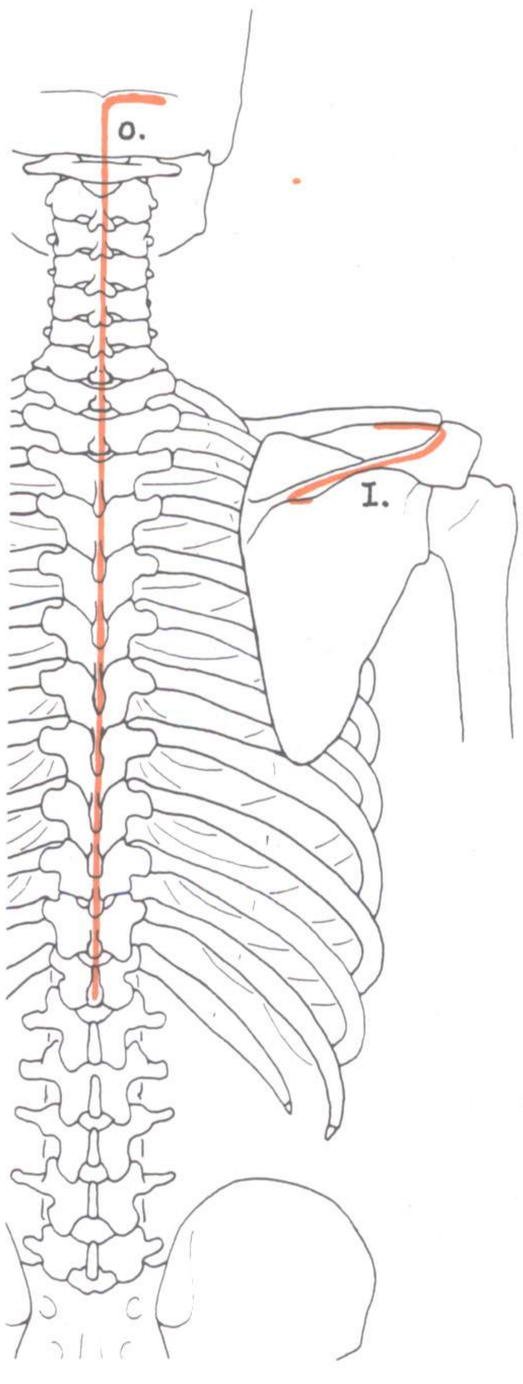
Ap *Aponeurosis* **CI** *Crest of ilium* **EO** *External oblique* **ES** *Erector spinae* **FF** *Flank fat pad* **GMa** *Gluteus maximus* **GMe** *Gluteus medius* **ILi** *Iliac line* **In** *Infraspinatus* **L** *Latissimus dorsi* **R** *Rib* **Rh** *Rhomboids* **SeA** *Serratus anterior* **TMa** *Teres major* **Tr** *Trapezius*
* *Under latissimus dorsi*

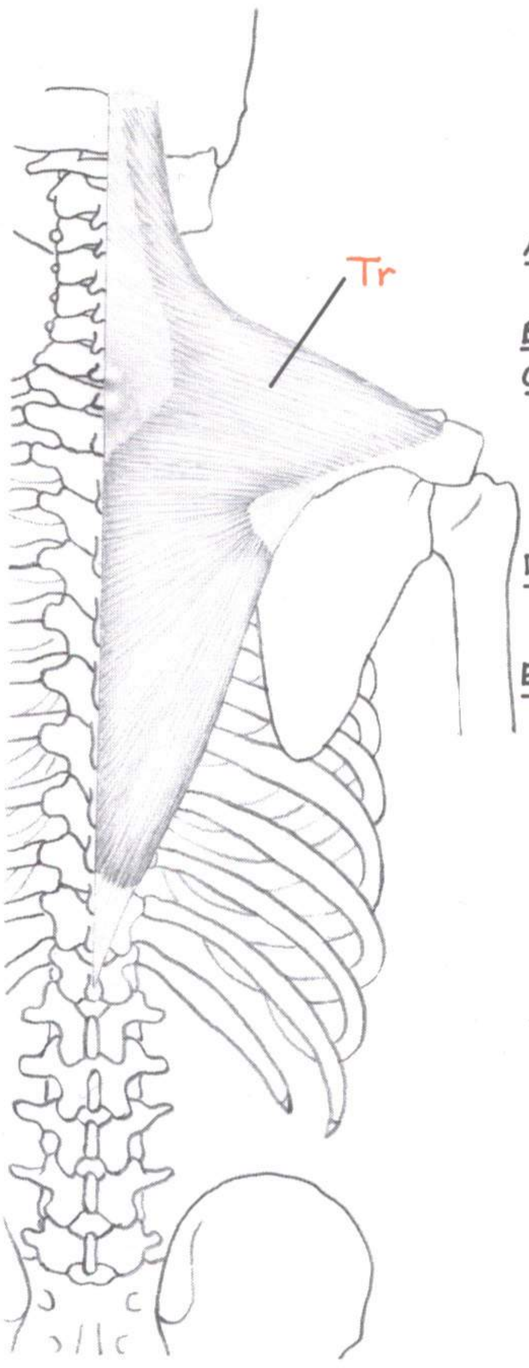


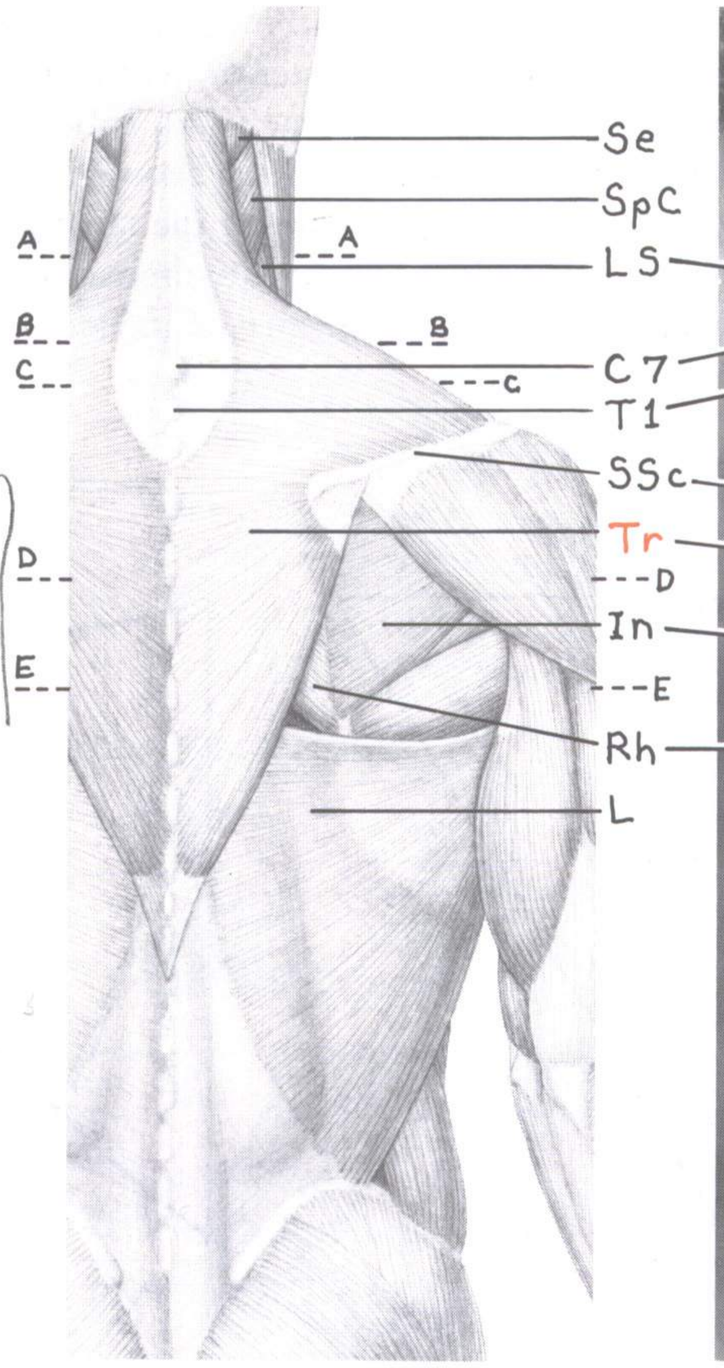
teres major, rib cage (and individual ribs), and especially the serratus anterior. These forms are more clearly seen when the trunk is flexed forward, the arm raised, and the shoulder slid forward, stretching and thinning the latissimus. The direct evidence of the latissimus on the surface, in order of prominence, is its lateral border, superior border, and the line of attachment of its muscular fibers into its tendon. The muscle sheet of the latissimus thickens as it approaches the armpit, filling the space surrounding the forms of the teres major and serratus anterior.

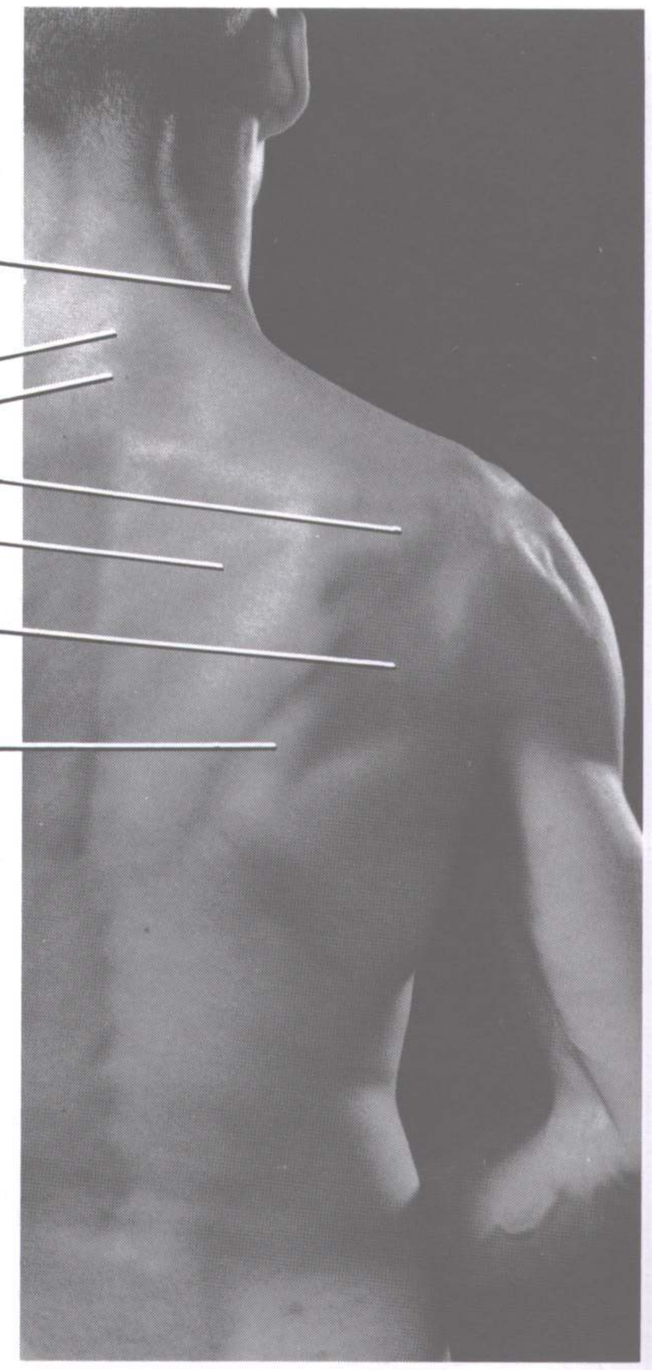


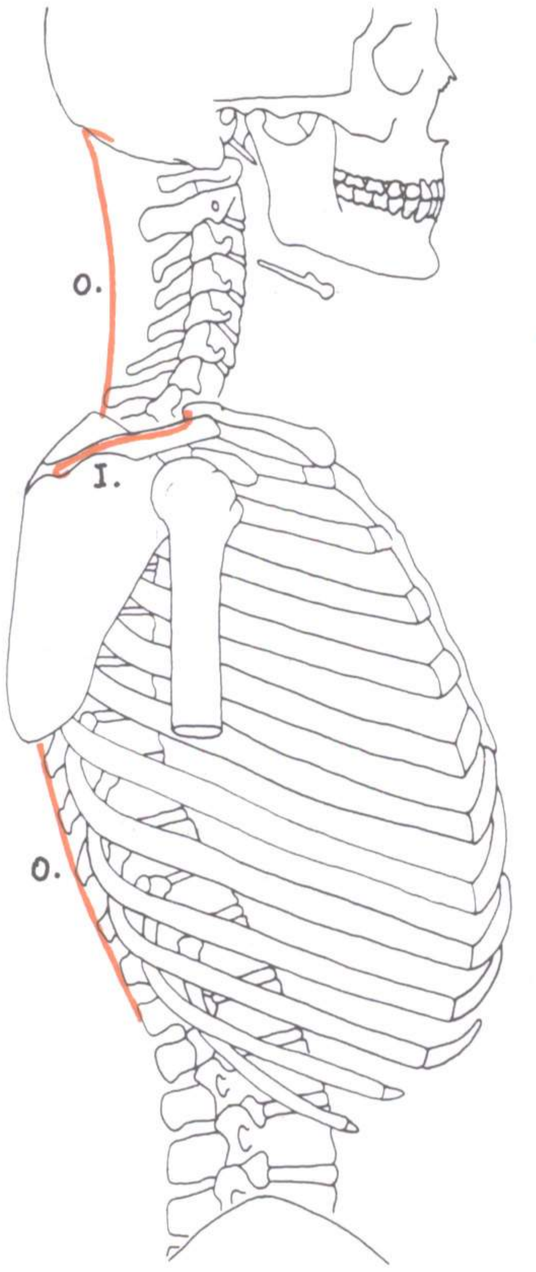


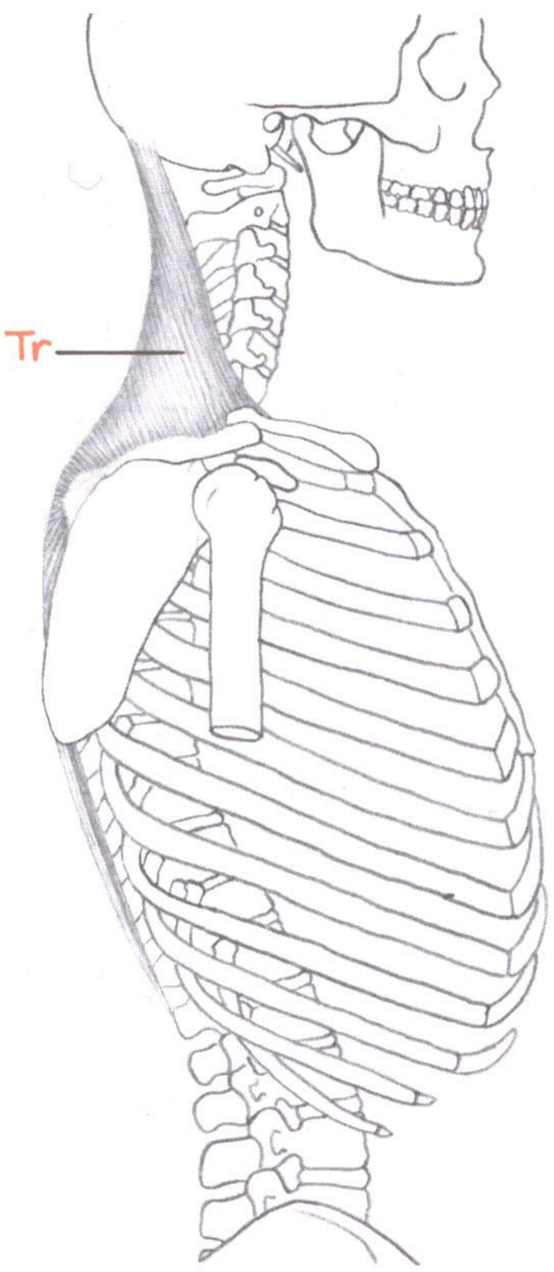


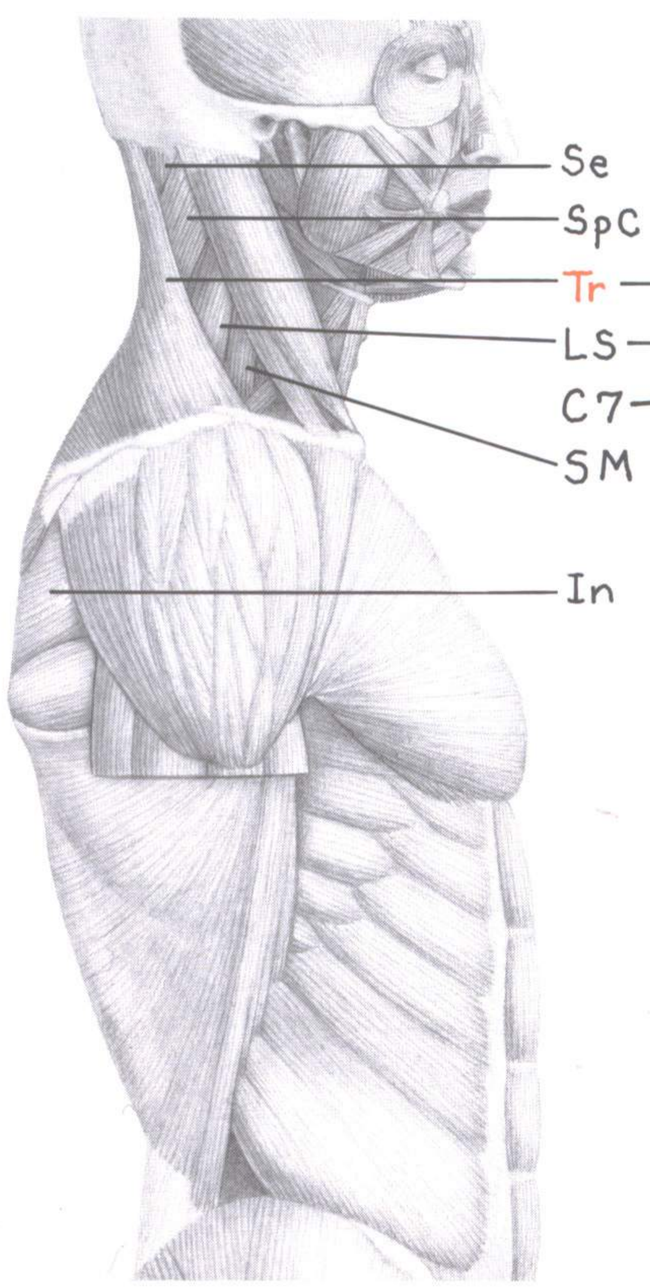


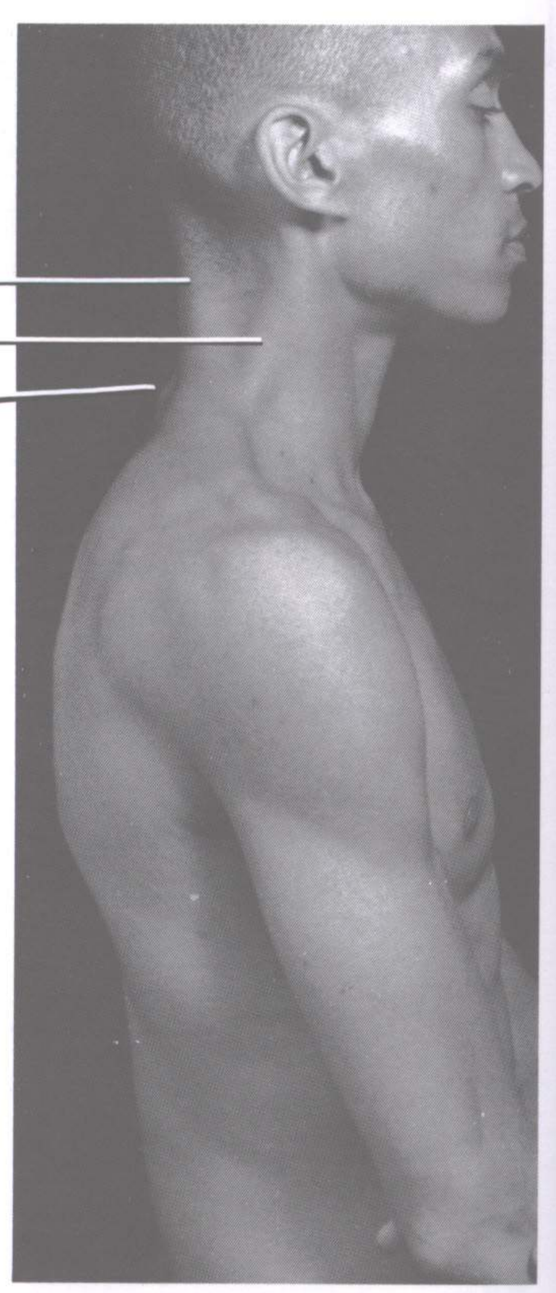




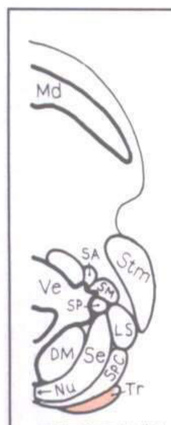




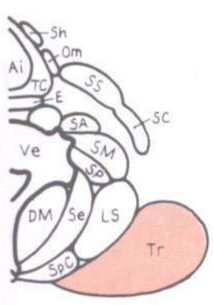




C7 *Seventh cervical vertebra* **ES** *Erector spinae* **In** *Infraspinatus* **L** *Latissimus dorsi*
LS *Levator scapulae* **Nu** *Nuchal ligament* **Rh** *Rhomboids* **S** *Scapula* **Se** *Semispinalis capitis*
SM *Scalenus medius* **SpC** *Splenius capitis* **SSc** *Spine of scapula* **T1** *First thoracic vertebra*
Tr *Trapezius* **Ve** *Vertebra*



SECTION A



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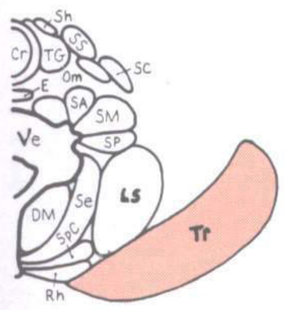

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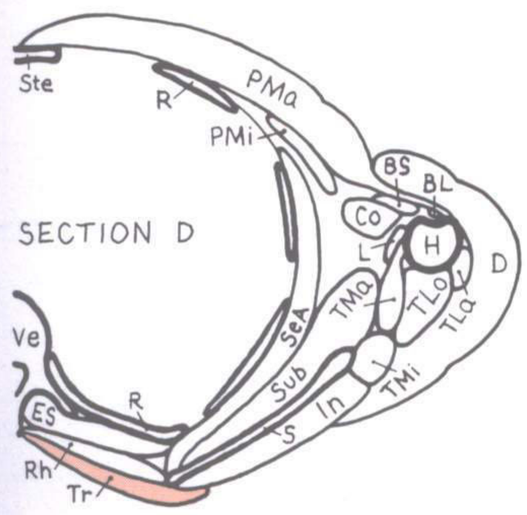
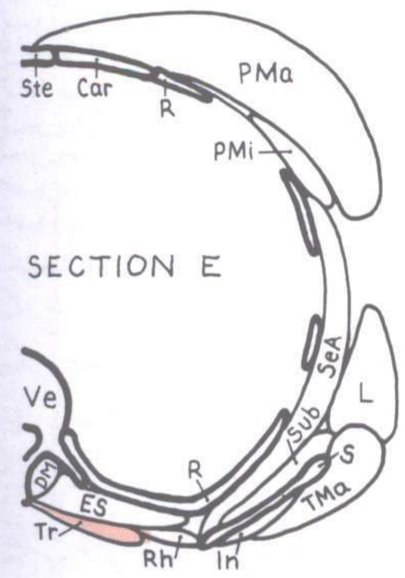




Trapezius

ORIGIN A line that passes across the medial third of the superior nuchal line, at the base of the skull, over to the external occipital protuberance. It then descends along the posterior free edge of the nuchal ligament, the vertebral spinous processes down to the twelfth thoracic vertebra, and the intervening supraspinal ligaments. The line of origin is an upside-down L.

INSERTION A continuous line that passes across the posterior border of the lateral third of the clavicle, onto the medial border of the acromion, and along the *upper* edge of the spine of the scapula (excluding the expanded triangular area at the spine's medial end). The line of insertion then doubles back around for a short distance along the *lower* edge of the spine of the scapula, ending at the tubercle of the spine. Seen from above, the line of insertion is a V, pointed laterally, on the top of the bony shoulder girdle.

ACTION Rotates the scapula by lifting its lateral end and pulling its medial end downward. Working separately, the upper portion lifts the scapula, the middle portion pulls it medially, and the lower portion pulls it downward.

STRUCTURE The trapezius is an extensive, wide, triangular muscle located on the back of the chest, the top of the shoulder, and the back of the neck.

The upper fibers of the trapezius pass downward and outward; the middle fibers pass horizontally outward; and the lower fibers pass upward and outward, heading toward the tubercle on the spine of the scapula via a small aponeurosis. The muscle varies in thickness in its different areas. The part on the back of the neck is very thin; along with the deep semispinalis capitis muscle it creates a muscular column on either side of the midline. The nuchal ligament lies on the midline of the back of the neck, at the bottom of the vertical groove between these columns when the neck is upright. It becomes a raised ridge when the head and neck are flexed forward. In side view, the back profile of the neck can be concave, straight, or convex.

In nonmuscular individuals, or when the scapula has been slid laterally and rotated so the upper portion of the trapezius becomes elongated and thin, the vertebral border of the scapula located above the base of the spine may become evident on the surface, beneath the muscle. When the arm is abducted, the oval form of the supraspinatus can be seen bulging deep to the trapezius just above the medial portion of the spine of the scapula.

The lowest fibers of the trapezius may separate visually, creating an independent elliptical or elongated form, directed upward and outward toward the scapular tubercle. This portion can be visualized as a separate flat muscle belly with flattened tendons at both ends.

The lower lateral edge of the trapezius can be seen passing obliquely upward and outward on the middle of the back; it is clearly seen when the arm is held horizontally out to the side and pushed down against resistance.

The entire trapezius can be reduced to three major planes: the back plane of the neck, the top plane of the shoulder, and the vertical plane of the back.

The majority of the trapezius creates the **vertical plane of the back,** also called the **rhomboid plane** (based on the orientation of the underlying rhomboid muscle). This vertical plane is directed medially and anteriorly from the vertebral border of the scapula to the spinous processes of the vertebrae on the midline of the body. The rhomboid planes of both muscles (both sides of the body), along with both **scapular planes** (the planes created by the infraspinatus and spine of the scapula), create a wide W configuration when *viewed from the top*. When the shoulder blades are pulled together in back, the rhomboid planes disappear and the trapezius muscles of both sides bulge and touch each other, producing a tight vertical cleft between them.

The **top plane of the shoulder,** for the most part, is directed upward and backward. The posterior edge of this plane is formed by the spine of the scapula. Anteriorly, the shoulder plane curves over the top of the shoulder.

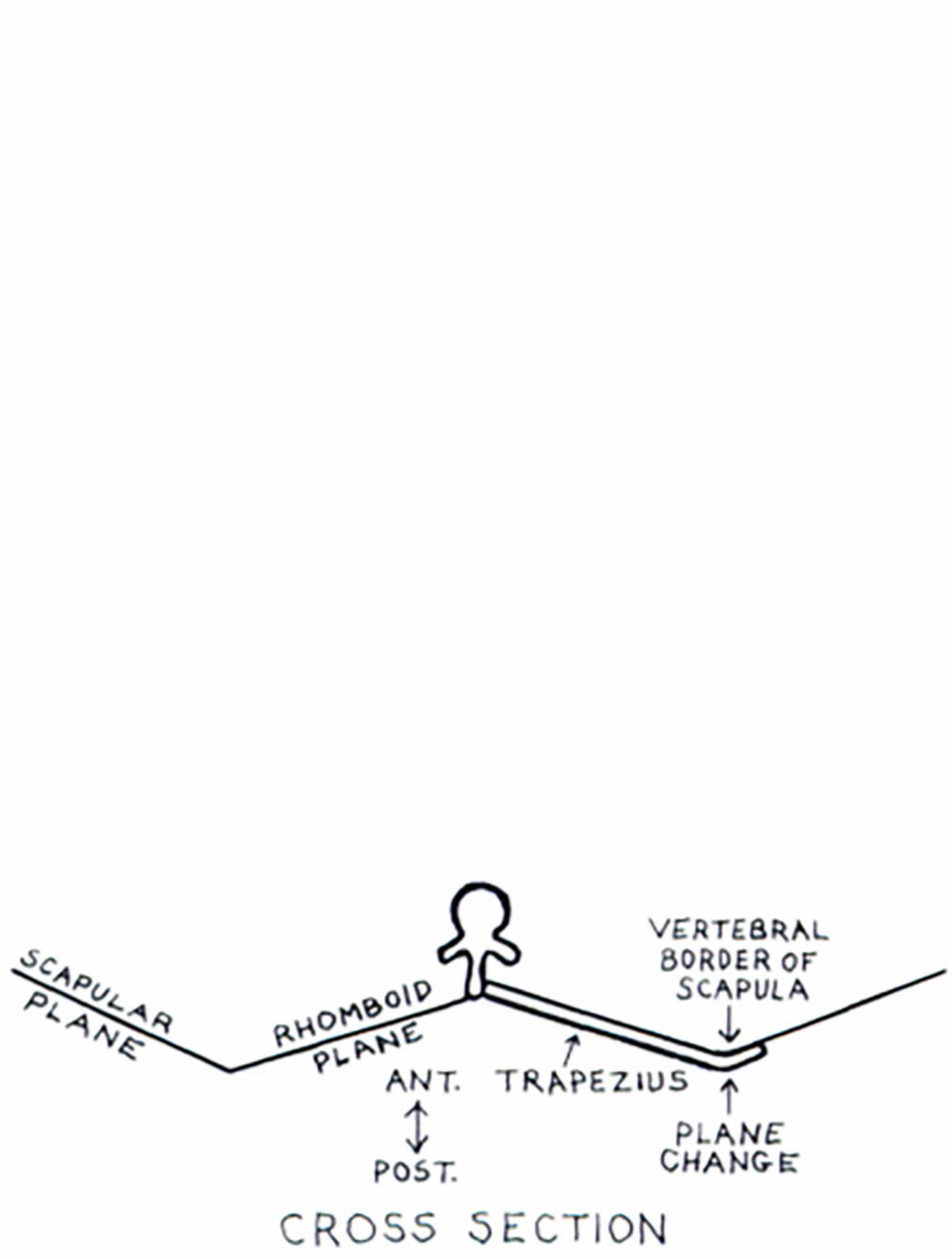
The **back plane of the neck,** created by the cervical portions of the trapezius of both sides of the body, can be visualized in two ways—on the one hand it is often flattened and planar, while at other times it is rounded (side to side) and participates in producing the cylindrical volume of the neck.

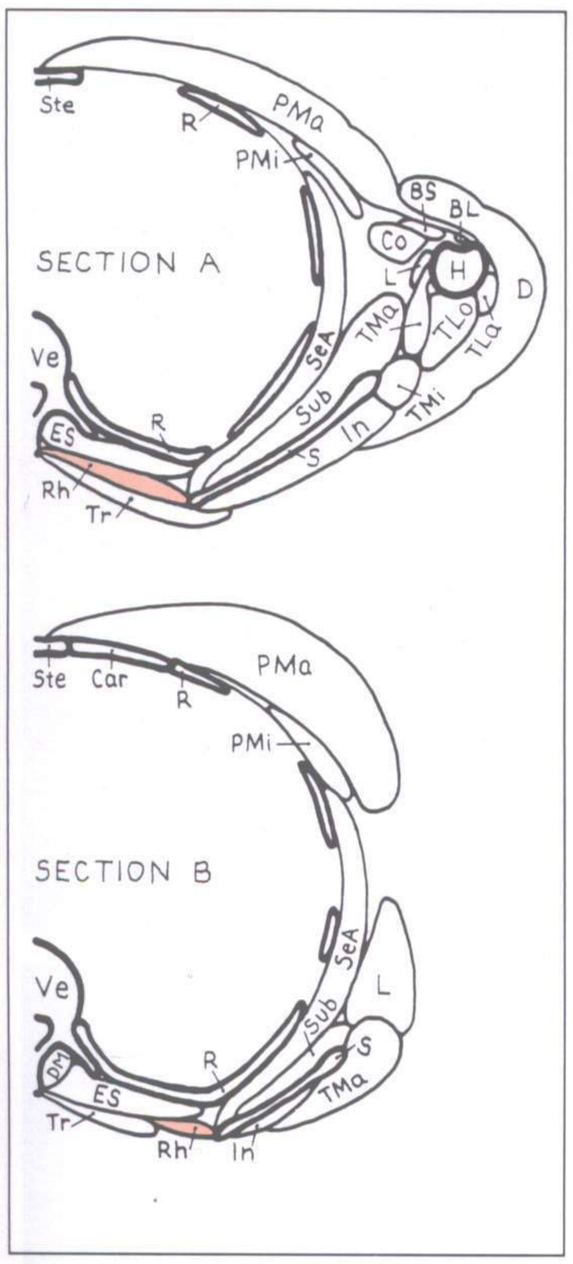
There are **three triangular aponeurotic** or **tendinous areas** in the trapezius, as follows:

1. A relatively **large triangular area surrounding the seventh cervical vertebra.** These tendinous areas of the muscles of both sides of the body create a diamond, oval, or teardrop-shaped depression, prolonged upward, on the back of the neck. It usually reaches up to the base of the skull and ends inferiorly at the level of the spinous process of the third thoracic vertebra. The prominent spinous processes of the seventh cervical and first thoracic vertebrae project at the center of this tendinous, depressed area.
2. A **smaller triangular area at the upper lateral end of the fibers of the lower half of the trapezius.** This tendinous area lies partially on the expanded triangular base of the me-

dial end of the spine of the scapula (which shows through as a bony plane) and partially on the surface of the infraspinatus muscle. The infraspinatus portion of the tendon may appear as a depression, caused by the fullness of the surrounding muscular and bony forms. The lower edge of this tendinous triangle can sometimes be seen constricting the muscular form of the infraspinatus. The lateral ends of the lower muscle fibers of the trapezius attach into the infraspinatus portion of the tendon in an elongated S-curve line which lies *lateral* to the underlying vertebral border of the scapula. This produces a plane change of the trapezius belly as its fibers pass over this scapular border; most of the belly lies medial to the vertebral border on the rhomboid plane, while only a very small portion of the belly lies lateral to it on the scapular plane. When the arm is abducted away from the side of the body, automatically rotating the scapula, the scapula and overlying infraspinatus slide out laterally from under the small scapular portion of the belly of the trapezius.

3. The **smallest triangular area at the inferior tip of the muscle.** It is this small triangular aponeurosis, not the actual muscle fibers, that reaches the very bottom of the line of origin of the trapezius (at the spinous process of the twelfth thoracic vertebra). Because this tendinous area is not visible as it lies on the erector spinae, the inferior end of the *form* of the muscular belly of the trapezius ends superior to the final attachment. The triangular tendinous areas of both sides of the body create a diamond shape, with the inferior ends of both sides of the *muscular form* of the trapezius ending in relief as an inverted V, or at least appearing blunt, rather than as a single sharp point.





Rhomboids
(Major and Minor Together)

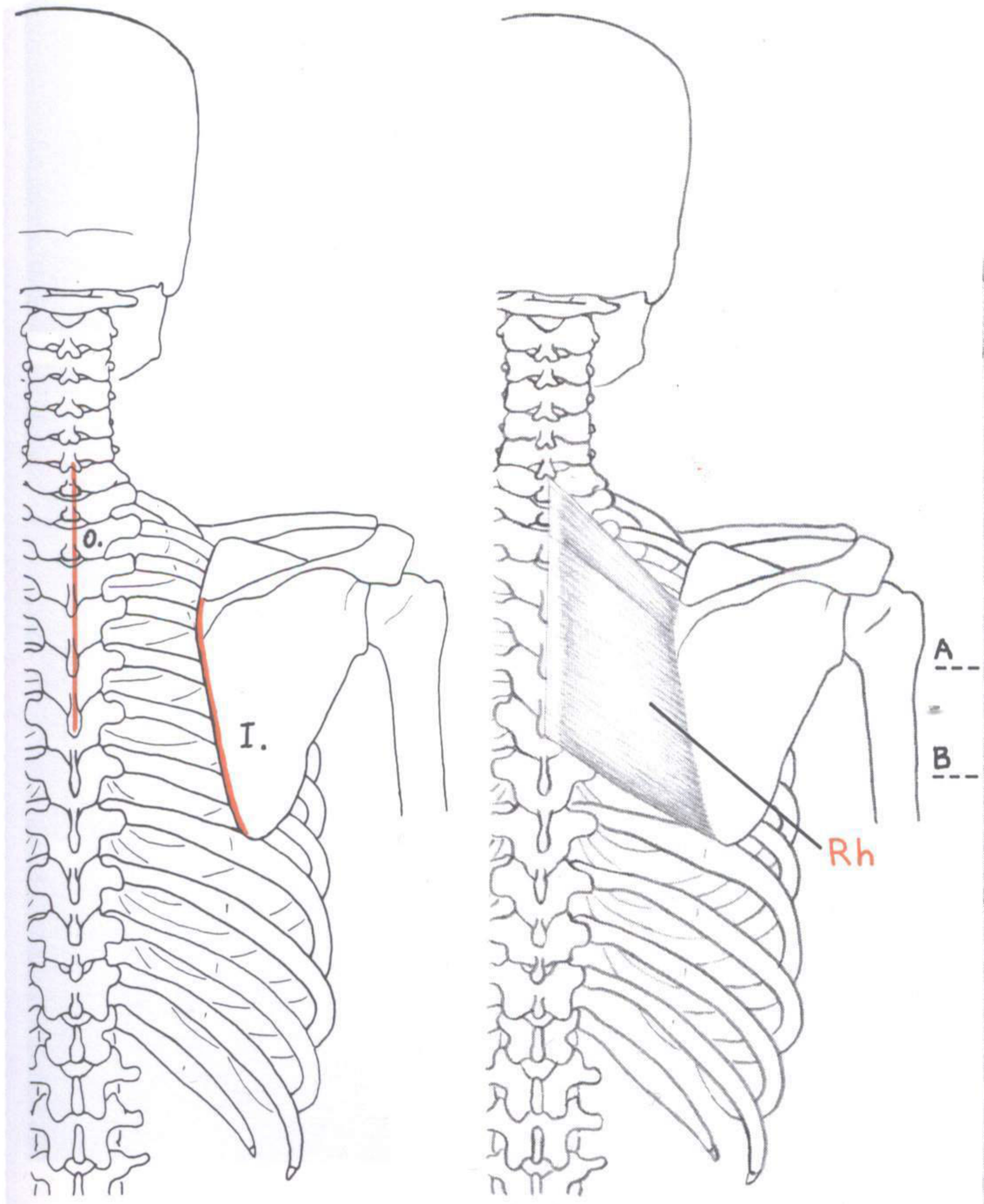
ORIGIN From the inferior portion of the nuchal ligament down to the fifth thoracic vertebra, along the spinous processes and interconnecting supraspinal ligament of the vertebrae (on the midline of the upper back).

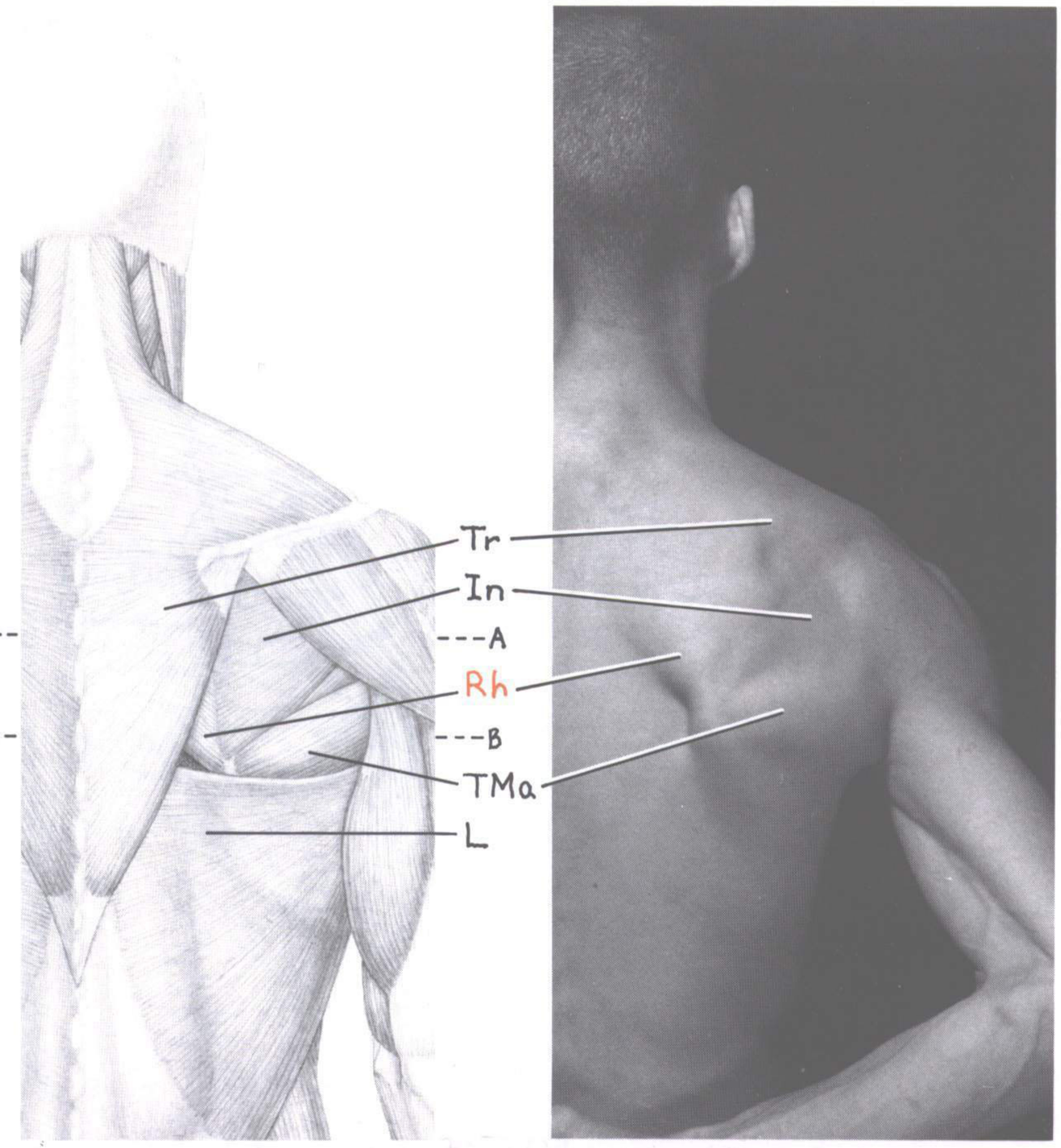
INSERTION The very edge of the medial (vertebral) border of the scapula, extending from the top of the triangular expansion of the base of the spine down to the inferior angle.

ACTION Together the rhomboids adduct and raise the scapula. They assist in rotating the scapula (during rotation, the bottom of the scapula moves medially and the acromion moves inferiorly).

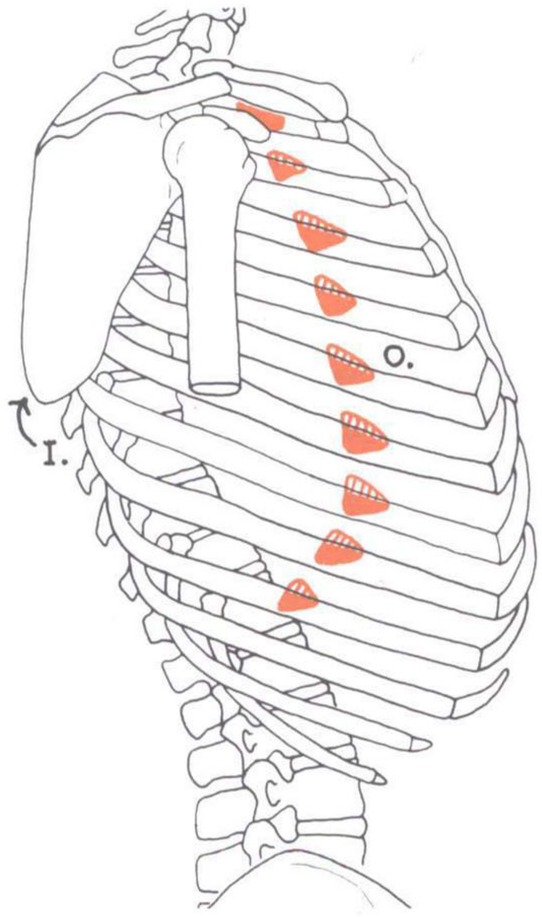
STRUCTURE The rhomboid major and rhomboid minor muscles are barely separable and are here considered as a single, flat, quadrilateral muscle on the upper back. When contracting and shortening (pulling the scapula towards the midline), the rhomboids may produce an oval bulge which can be seen under the trapezius. This form lies closer to the scapula than to the midline of the back.

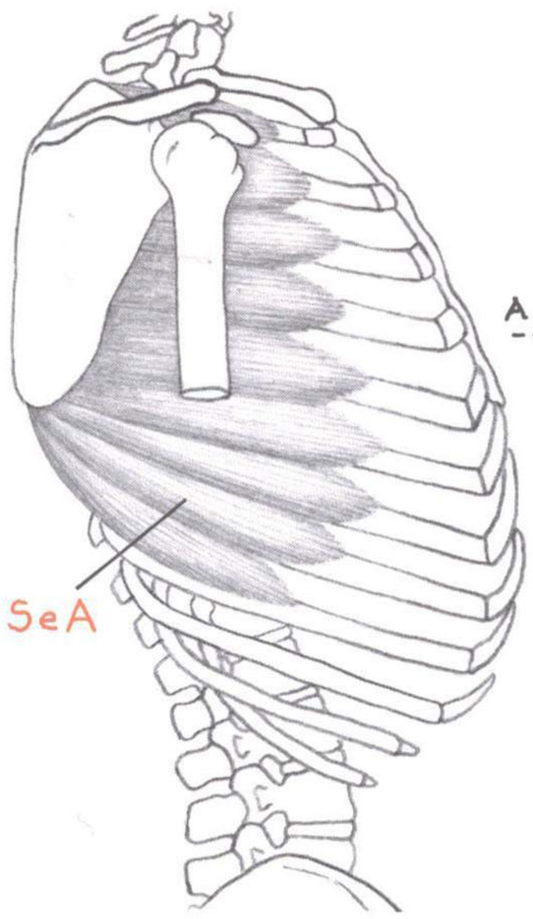
The lateral portion of the oblique inferior border of the muscle is superficial, but is not always easily seen. It lies in the triangular space bordered by the medial border of the scapula, the lateral edge of the trapezius, and the top edge of the latissimus dorsi. The rest of the inferior edge can sometimes be seen *under* the trapezius, heading diagonally upward and medially to its attachment on the vertebral column. Any line or form directed *upward and medially* from the inferior angle of the scapula to the midline is part of the rhomboids, not the trapezius.

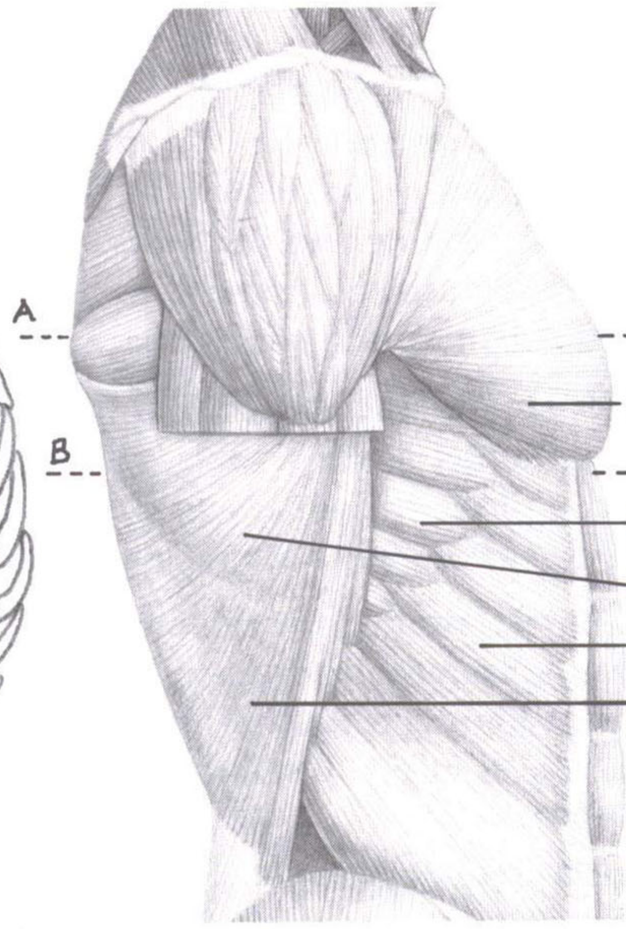


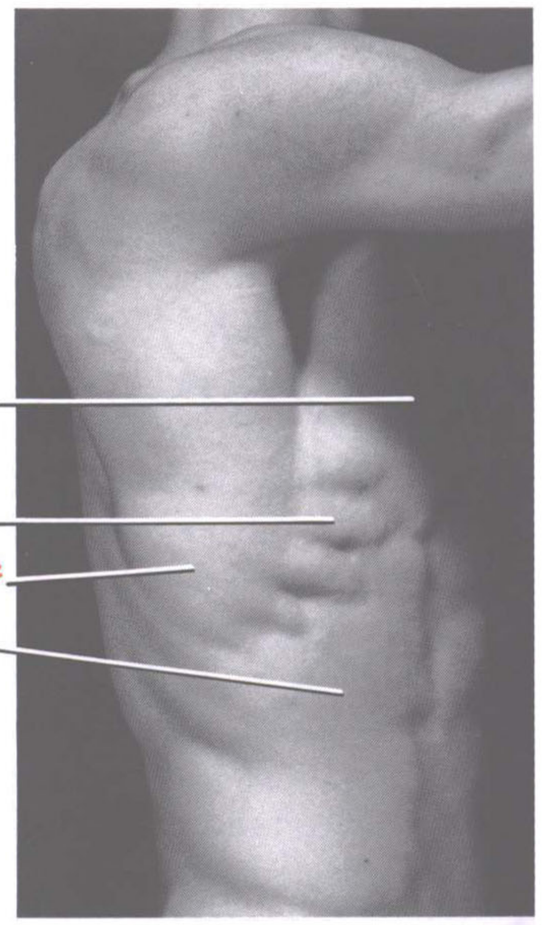


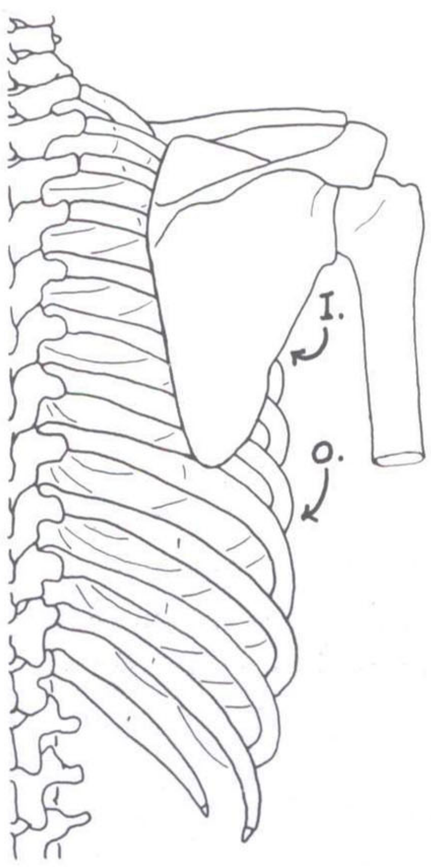
ES *Erector spinae* **In** *Infraspinatus* **L** *Latissimus dorsi* **Rh** *Rhomboids* **S** *Scapula* **TMa** *Teres major* **Tr** *Trapezius* **Ve** *Vertebra*

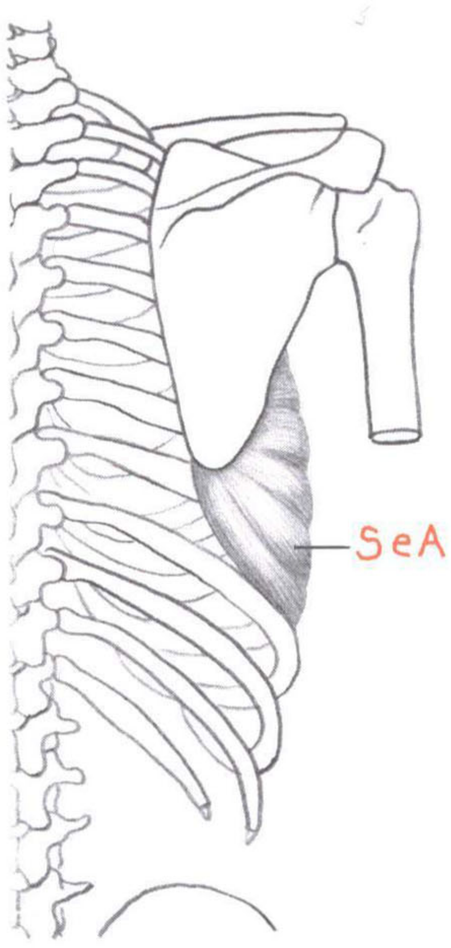


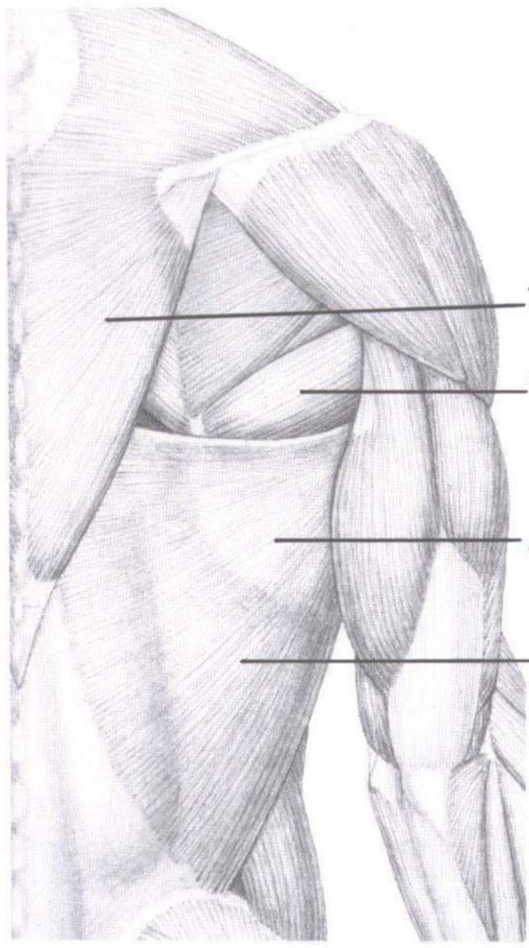


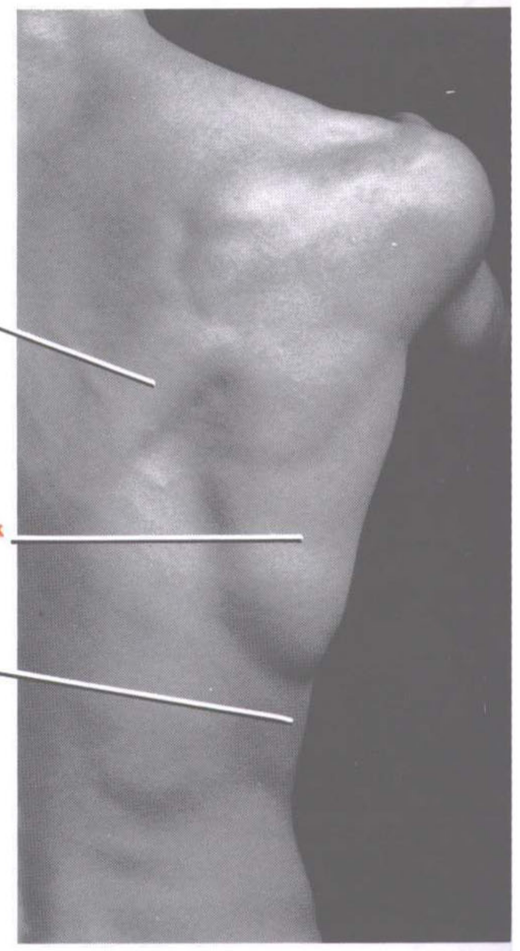


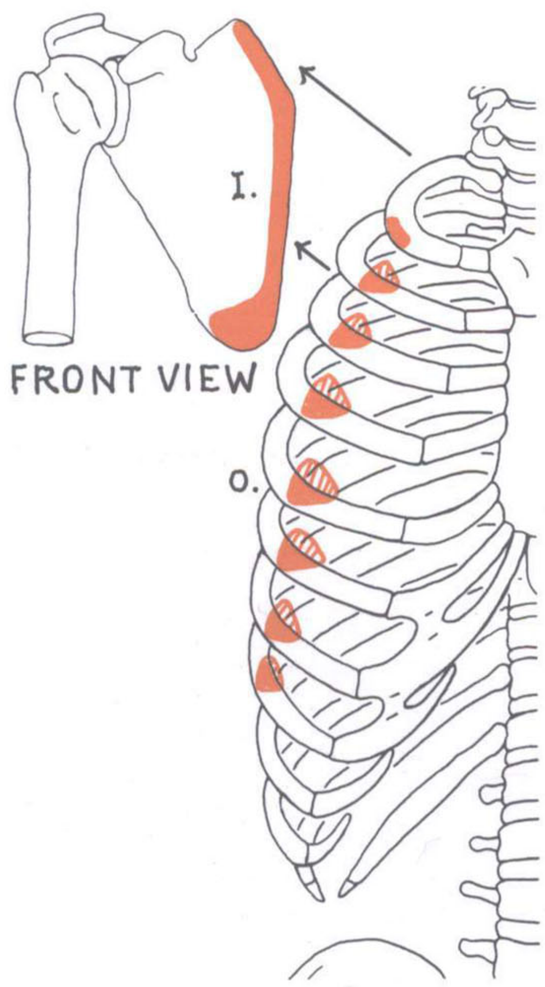


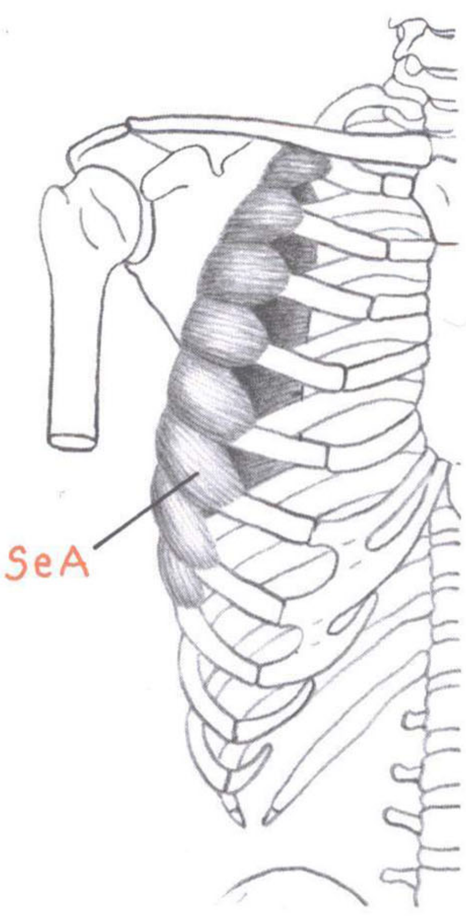


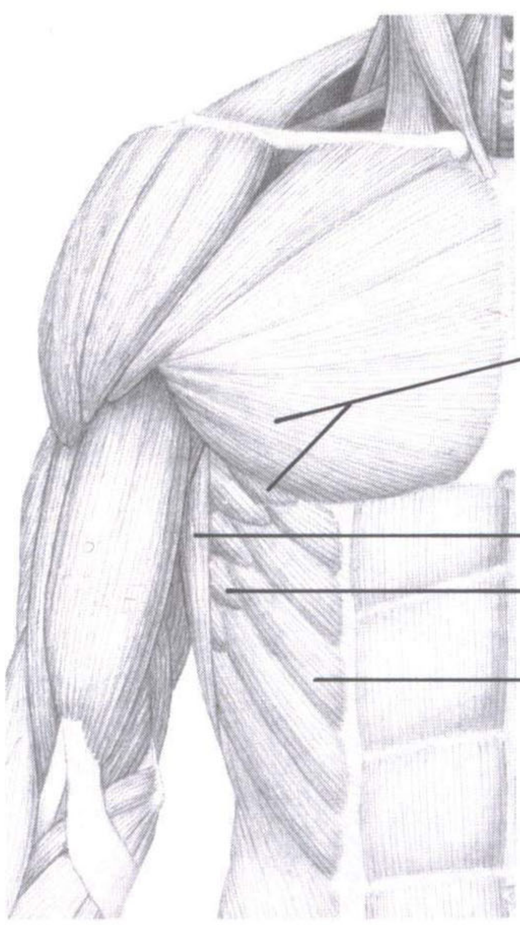


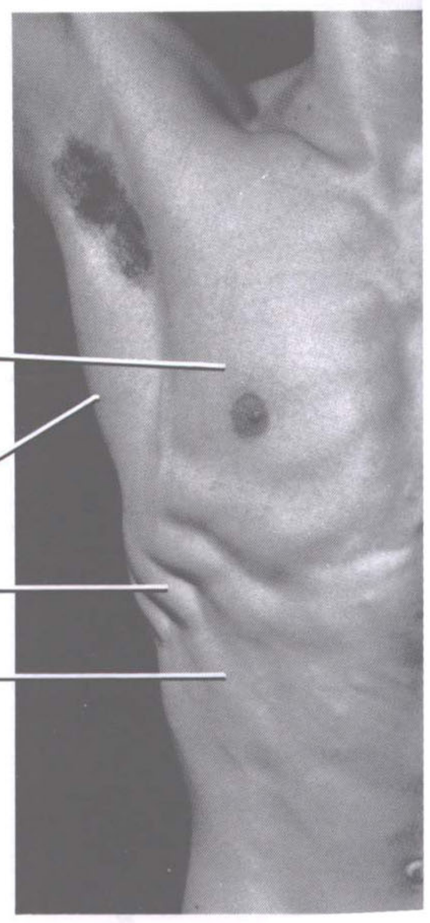




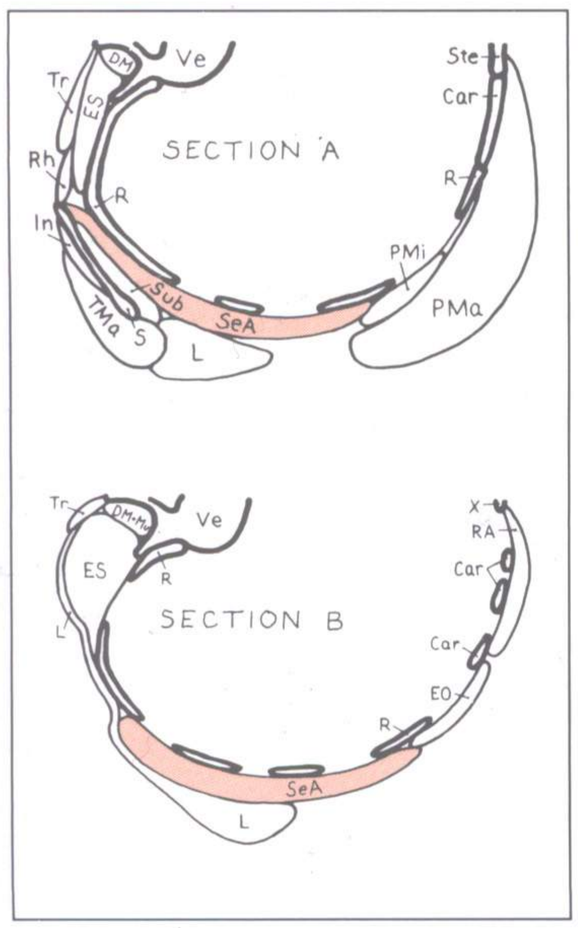








EO *External oblique* **L** *Latissimus dorsi* **PMa** *Pectoralis major* **PMi** *Pectoralis minor* **R** *Rib*
S *Scapula* **SeA** *Serratus anterior* **Sub** *Subscapularis* **TMa** *Teres major* **Tr** *Trapezius*
* *Under latissimus dorsi*



Serratus Anterior (Serratus Magnus)

ORIGIN A line of small triangular areas on the outer surfaces and superior borders of the first eight or nine ribs and the aponeuroses covering the intervening intercostal muscles.

INSERTION Narrow strip on the costal (deep) surface of the scapula at its vertebral border, which expands in area at the inferior angle of the scapula.

ACTION Slides the scapula around forward, as in punching, and by its inferior fibers rotates its inferior angle laterally, which elevates the lateral end of the shoulder, and therefore the arm.

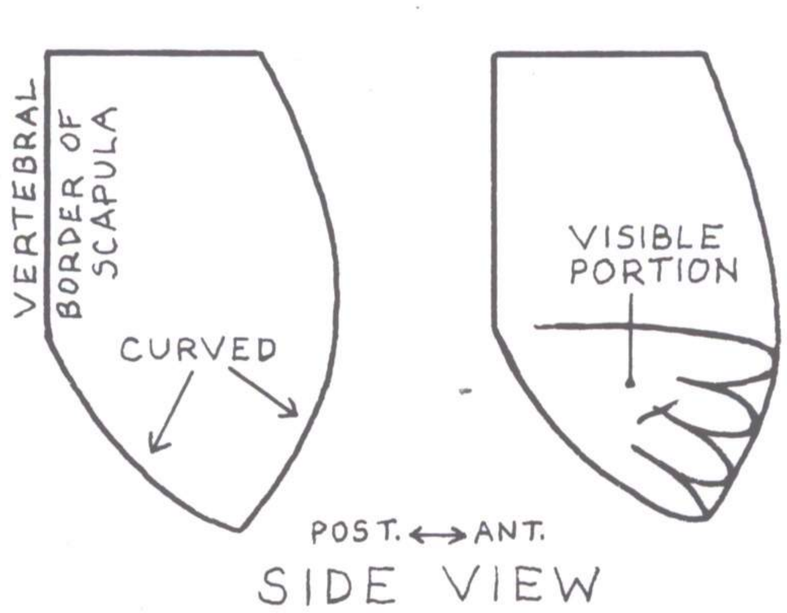
STRUCTURE When considered in its entirety, the serratus anterior is a large quadrilateral muscle which embraces the curved form of the rib cage. It is divided into fingerlike digitations (bundles), each originating from an area on the side and upper border of a rib and the intercostal space above. The muscle can be subdivided into upper and lower portions. The **upper portion** partially lies inconspicuously against the upper side of the rib cage in the armpit and partially sits sandwiched between the scapula and rib cage.

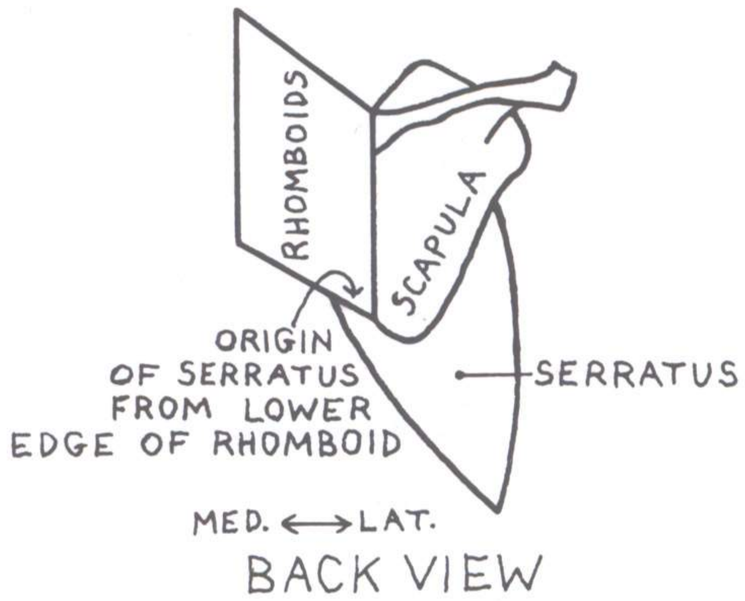
The **lower portion** consists of five or six pointed digitations which create a thick, fan-shaped mass radiating forward from the inferior angle of the scapula. Only the lowest three or four of these digitations can be seen—their anterior half is superficial on the side of the chest (where they interdigitate with the bundles of the external oblique), but as they head toward the inferior angle of the scapula, they pass deep to the latissimus dorsi; however, the form of the lower portion remains visible under the thin latissimus. The uppermost visible digitation begins at or just above the level of the inferior border of the pectoralis major. The digitations can begin quite far forward on the side of the rib cage, almost reaching the front of the chest.

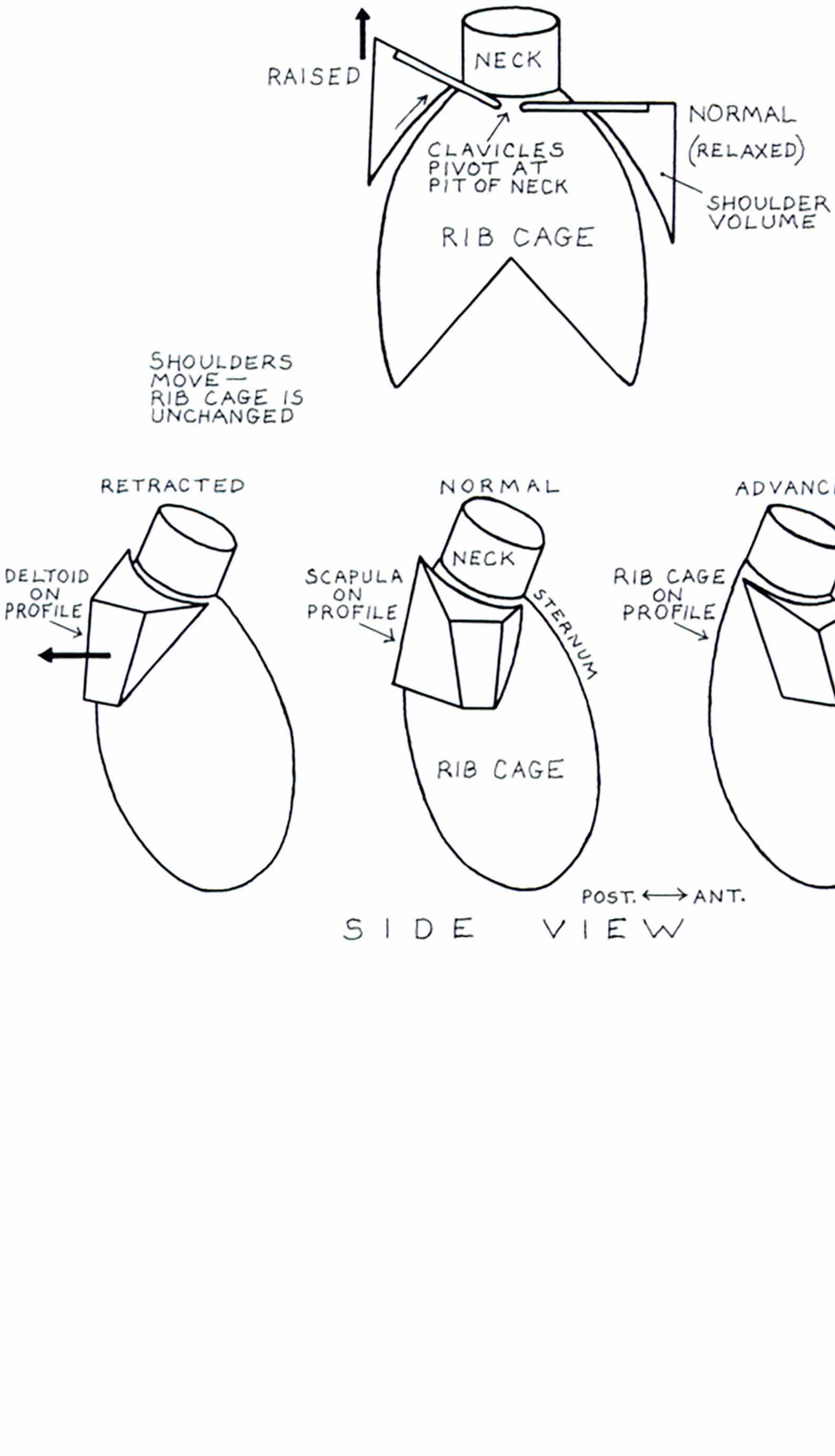
The line of origin of the tips of the exposed digitations on the side of the rib cage forms a toothed (serrate), anteriorly curved line, which appears to be directed from the nipple to the posterior superior iliac spine when looking at the figure in side view. Therefore, the length of the exposed part of each of the digitations, from its tip to the lateral border of the latissimus dorsi, diminishes inferiorly. Sometimes the tip of the lowest digitation may be completely hidden from view under the front edge of the latissimus, especially if the latissimus is drawn forward in the advanced shoulder.

The digitations of the serratus anterior are bulged and more horizontal than the flatter and more oblique digitations of the external oblique. The ribs, often seen under the external oblique, are not seen under the serratus.

The inferior border of the serratus anterior will sometimes continue inserting past the inferior angle of the scapula into the lower edge of the rhomboid major muscle for a short distance; consequently, the form of the serratus under the latissimus will extend further medially.



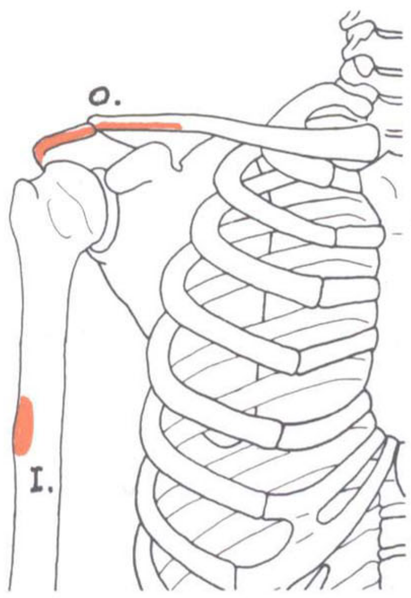


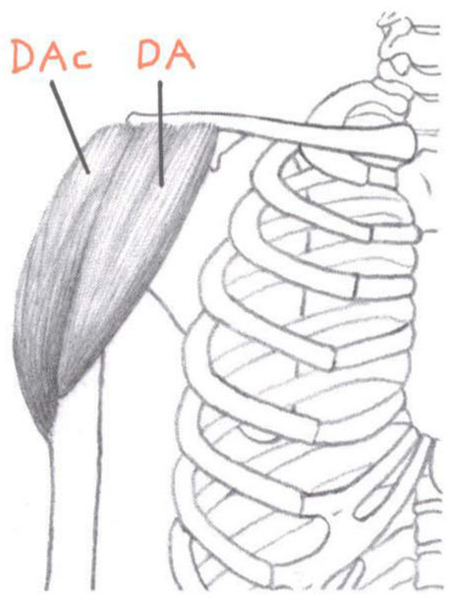

RAISED
NECK
NORMAL
(RELAXED)
CLAVICLES
PIVOT AT
PIT OF NECK
SHOULDER
VOLUME
RIB CAGE
SHOULDERS
MOVE—
RIB CAGE IS
UNCHANGED
RETRACTED
DELTOID
ON
PROFILE
NORMAL
NECK
SCAPULA
ON
PROFILE
STERNUM
RIB CAGE
ADVANCED
RIB CAGE
ON
PROFILE
POST. ⟷ ANT.
SIDE VIEW

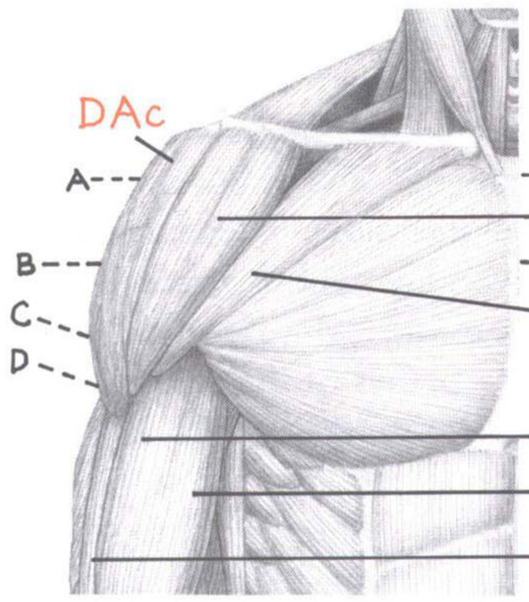
The Shoulder Muscles

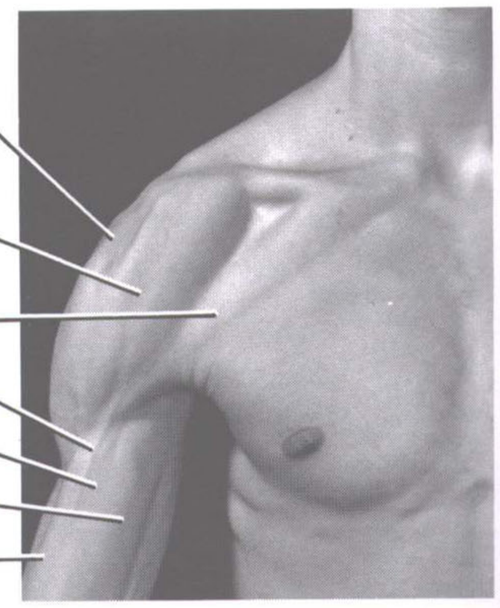
The *SHOULDER*, consisting of the bony shoulder girdle (scapula and clavicle) and its associated musculature, is a pyramidal structure that surmounts, and glides upon, the rib cage. The shoulders move independently of each other, which may tend to confuse the basic (and very important) form of the rib cage beneath, as well as the planes of the chest and back.

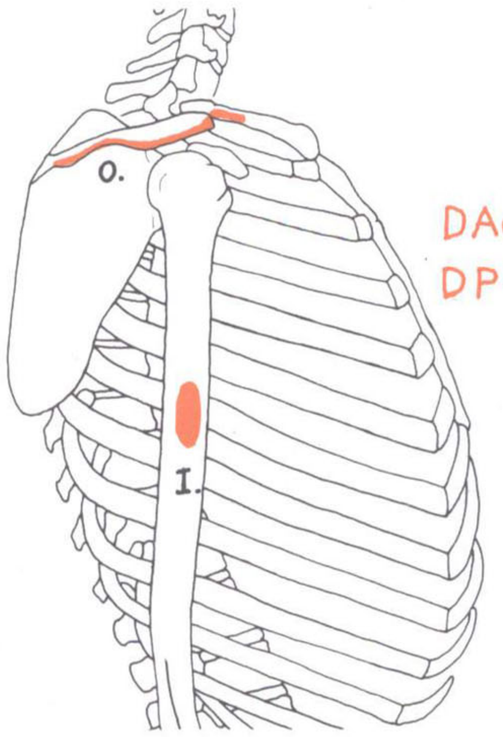
The **armpit,** or **axilla,** is the negative space or concavity situated within (at the bottom of) the structure of the shoulder. It is pyramidal in shape, with its apex directed superiorly (toward the top of the shoulder). The four sides of the armpit are created by the inner surface of the upper arm, the lateral surface of the rib cage (covered by the serratus anterior), and the anterior and posterior walls of the armpit. The anterior wall of the armpit is made up of the pectoralis major and pectoralis minor; the posterior wall, by the teres major and latissimus dorsi. The posterior wall is larger and extends further laterally than the anterior wall; it can be seen from the front view. The cavity of the armpit can be deepened by tensing the shoulder muscles. The armpit disappears almost completely when the arm is raised straight up. The armpit is variably filled by fat, and its depth is due to the amount of accumulation of fat in this region.

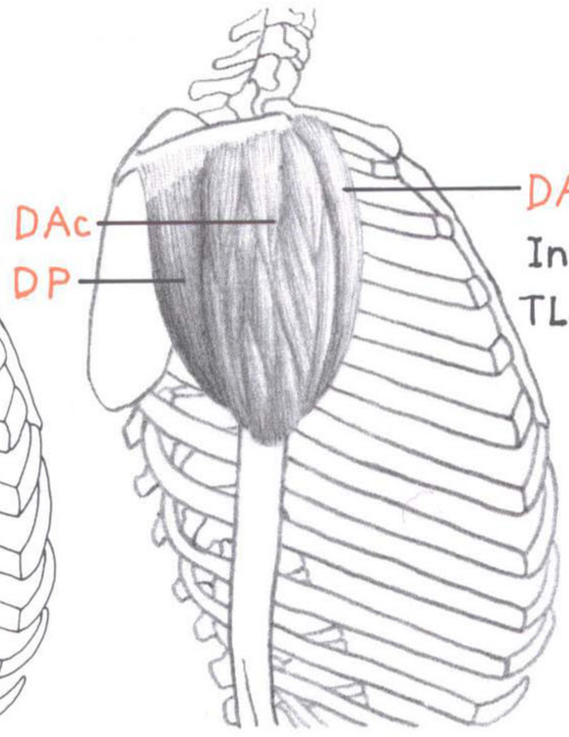


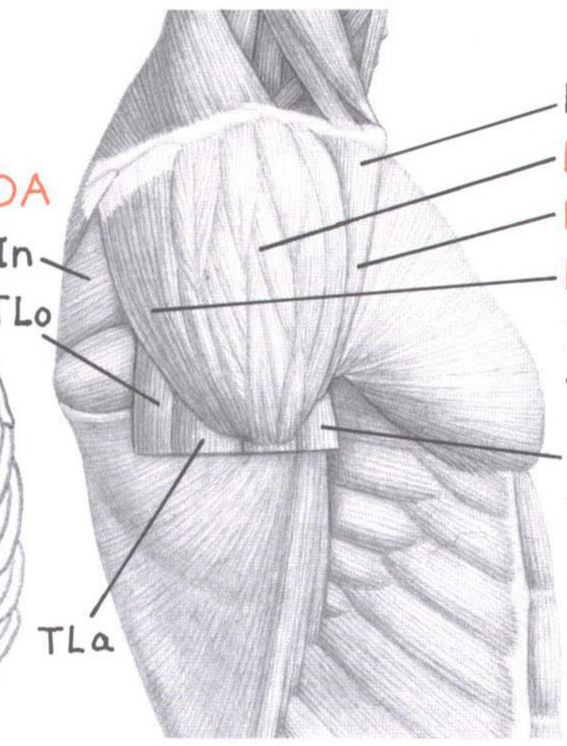


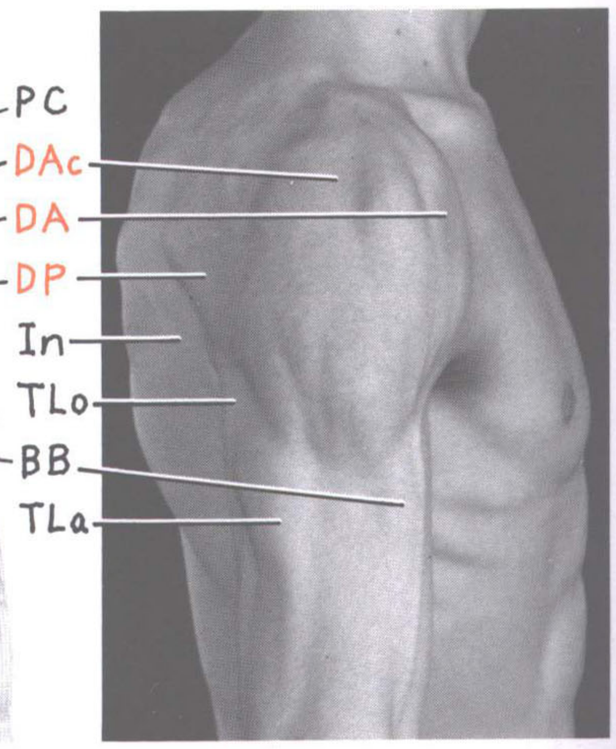


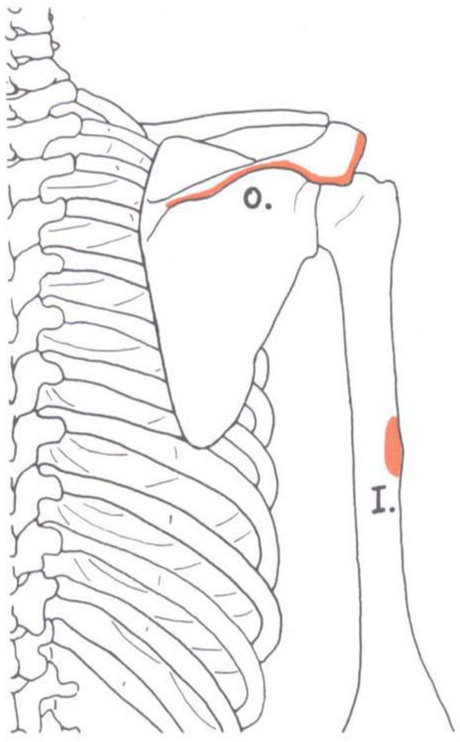


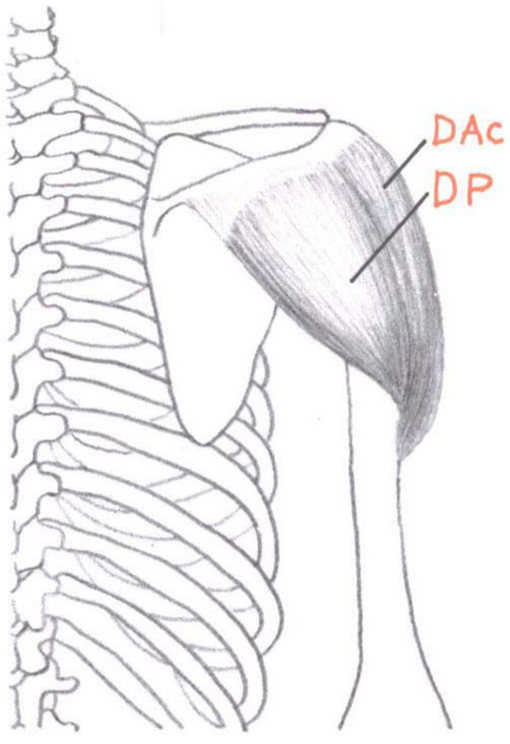


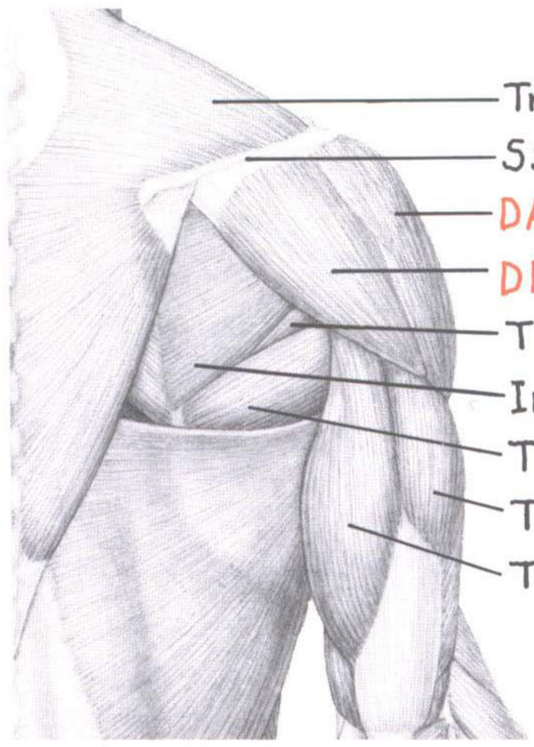


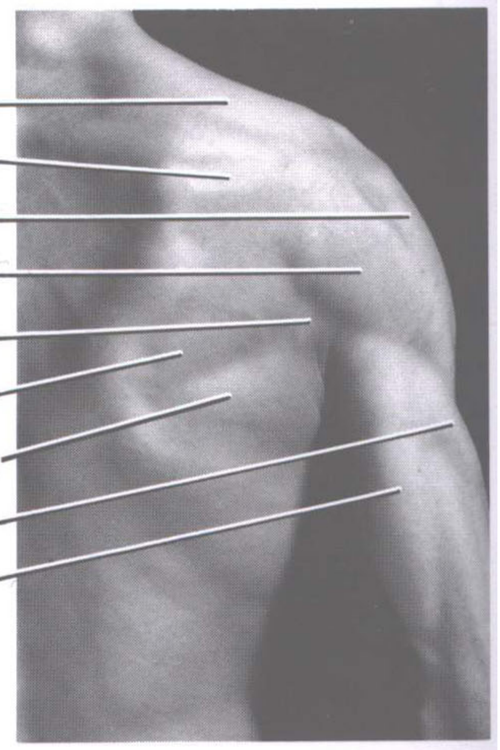


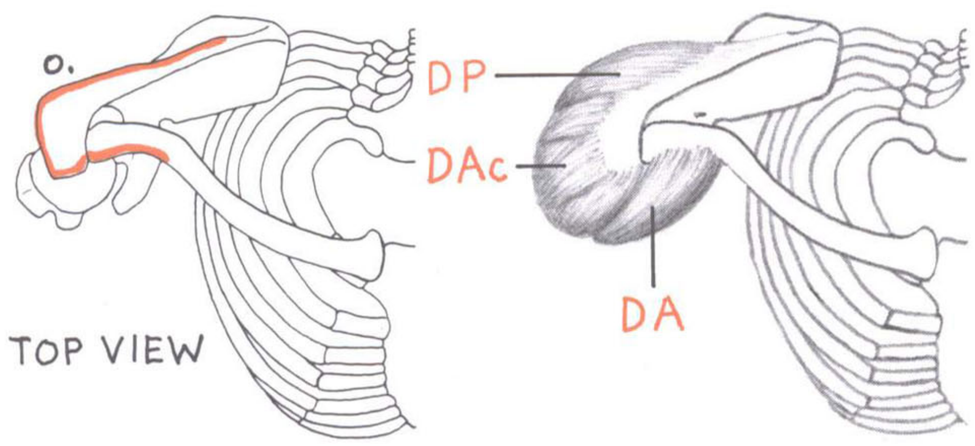


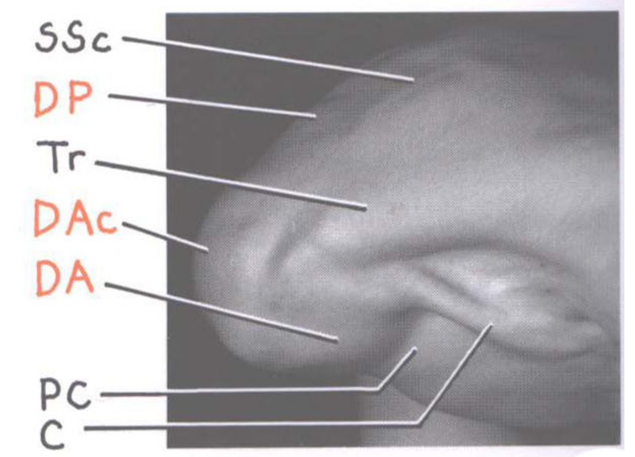




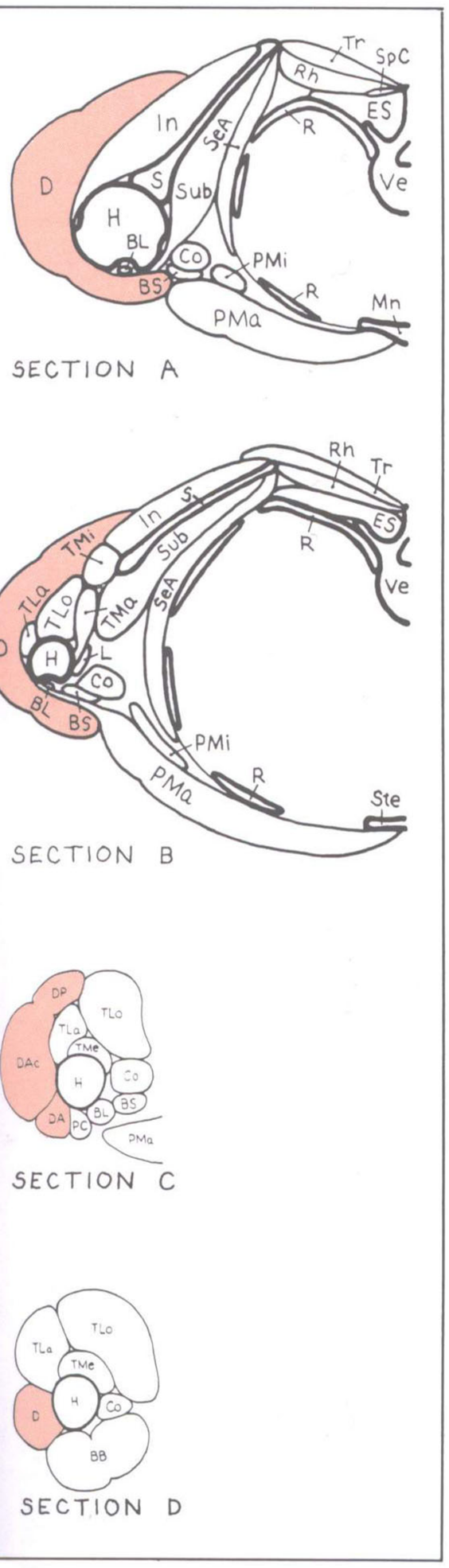








BB *Biceps brachii* **BL** *Biceps brachii—long head* **Br** *Brachialis* **BS** *Biceps brachii—short head*
C *Clavicle* **CV** *Cephalic vein* **D** *Deltoid* **DA** *Deltoid—anterior portion*
DAc *Deltoid—acromial portion* **DP** *Deltoid—posterior portion* **H** *Humerus* **In** *Infraspinatus*
PC *Pectoralis—clavicular portion* **PMa** *Pectoralis major* **SSc** *Spine of scapula*
TLa *Triceps—lateral head* **TLo** *Triceps—long head* **TMa** *Teres major* **TMi** *Teres minor*
Tr *Trapezius*



Deltoid

ORIGIN A continuous line passing along the anterior surface of the lateral third of the clavicle, the external border and adjacent top surface of the acromion of the scapula, and the lower edge of the spine of the scapula (extending medially up to, but not including, its medial triangular expansion). The deltoid roughly originates just below the insertion of the trapezius (the scapular spine remains subcutaneous).

INSERTION The deltoid tuberosity halfway down the outside of the shaft of the humerus.

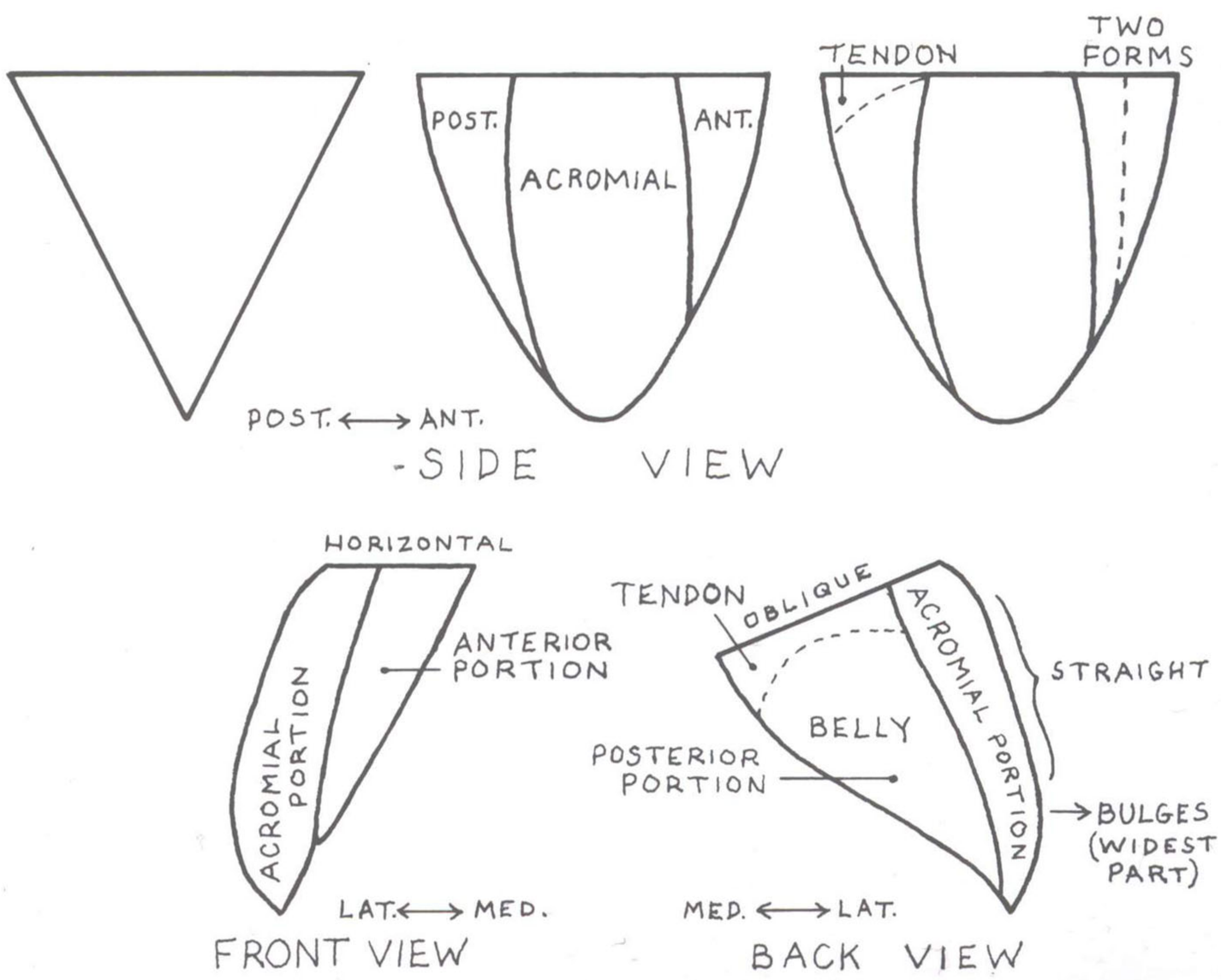
ACTION The anterior portion flexes the arm (raises it in front of the body) and pulls the horizontal arm toward the front of the body; the middle acromial portion powerfully abducts the arm; and the posterior portion extends the arm backward and pulls the horizontal arm backward. The anterior and posterior portions are antagonists when they flex and extend the arm at the shoulder joint.

STRUCTURE The deltoid is a thick triangular muscle, pointed inferiorly, which cups the shoulder joint. The muscle is divided into three portions: an anterior (clavicular) portion, an acromial (middle) portion, and a posterior portion. In front, the deltoid and pectoralis major are separated for a short portion of their lengths, just below the clavicle, by a triangular depression called the **infraclavicular fossa.**

The **anterior portion** of the deltoid, originating from the clavicle, is shorter than the other two portions. It shows up as a teardrop or oval relief on the surface, and sometimes splits down the middle into two forms. The lateral form descends slightly further. The belly of the anterior portion ends in its own wide tendon a short distance above the final insertion on the humerus. This belly, and the belly of the clavicular portion of the pectoralis major, end at about the same level (the anterior portion of the deltoid actually descends slightly further). The fibers, and therefore the forms, of these two muscles lie side by side—the deltoid does not cover the muscular fibers of the clavicular pectoralis; however, the *tendon* of the clavicular pectoralis (without fibers) *does* pass under the anterior deltoid. The tendon of insertion of the anterior portion of the deltoid then descends on the front (not outer) surface of the acromial fibers of the deltoid and inserts toward the front surface of the humerus, adjacent to the origin of the brachialis. It is actually the other two portions of the deltoid that insert onto the outside of the humerus.

The anterior portion of the deltoid projects anteriorly owing to the forward projection of the underlying spherical proximal extremity of the humerus, especially when the arm is hyperextended back past the trunk.

The **posterior portion** of the deltoid is located on the back of the shoulder. It thins into an



aponeurosis as it heads upward and medially toward its origin on the spine of the scapula. Because the posterior portion attaches via an unseen aponeurosis, its superior end may appear to "float" in relief on the surface of the infraspinatus. When the arm is raised, the posterior portion slides upward, exposing more of the infraspinatus.

The anterior and posterior portions are each made up of parallel muscle bundles. The **acromial portion,** however, is multipennate, and its oblique fibers originate from approximately four parallel tendons coming off the acromion and insert into approximately three tendons coming up from the shaft of the humerus. This creates a complicated "braided" effect in this portion of the muscle, with the fibers forming numerous slender bundles—some parallel to each other, others not. They may show up as a series of alternating forms, interdigitating as they descend from above and rise from below.

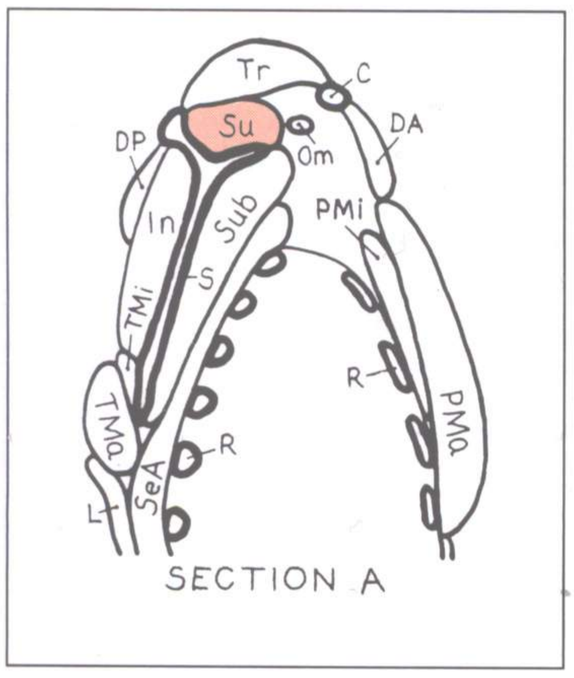
When the humerus is medially rotated, the acromial portion as a whole (with its numerous bundles) spirals slightly forward in its descent. The fibers of the anterior and posterior portions of the deltoid do not reach the inferior point of insertion, only the acromial portion does.

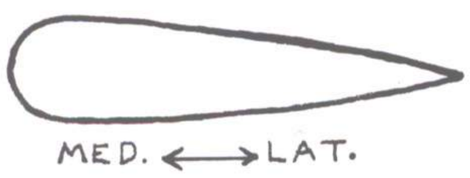
The acromial portion originates from the entire front and outer edges of the acromion. It is thickest below its center, which is the widest point of the muscle (and of the shoulder). Looking at the deltoid from the front view, after it comes off its bony origin, the outer profile is straight superiorly and full and rounded inferiorly, mostly because of the thickening of the lower acromial fibers. When the humerus is medially rotated, the posterior portion spirals around and down from the back to the outside of the shoulder, adding fullness at the lower end of the outer profile. The outer profile may then show an interruption in its line as the posterior portion (or occasionally the posterior acromial fibers) curves around forward and comes into view on the outer profile.

The separation between the acromial and anterior portions is more pronounced than the separation between the acromial and posterior portions.

One must be aware of the fact that as the humerus is rotated, the insertion of the deltoid rotates with it, affecting the transition of the deltoid between the shoulder and the arm; for instance, when the hands are placed on the hips (and the elbows are directed outward), the humerus is medially rotated, and the insertion of the deltoid faces forward, not outward (take note of the location of the medial epicondyle of the humerus).

When the arm is raised straight up, the line of origin of the deltoid on the clavicle and acromion becomes a furrow lodged between the forms of the deltoid and trapezius; the furrow is wider over the acromion. Also, the acromial fibers now spring from the *top* surface of the acromion near its edge, so that the edge of the acromion is no longer seen and the remaining subcutaneous area of the top surface of the acromion is reduced. A skin fold develops where the acromial fibers attach into the top of the acromion.





Supraspinatus

ORIGIN Medial two-thirds of the posterior surface of the scapula superior to the spine *(supraspinatus fossa)*.

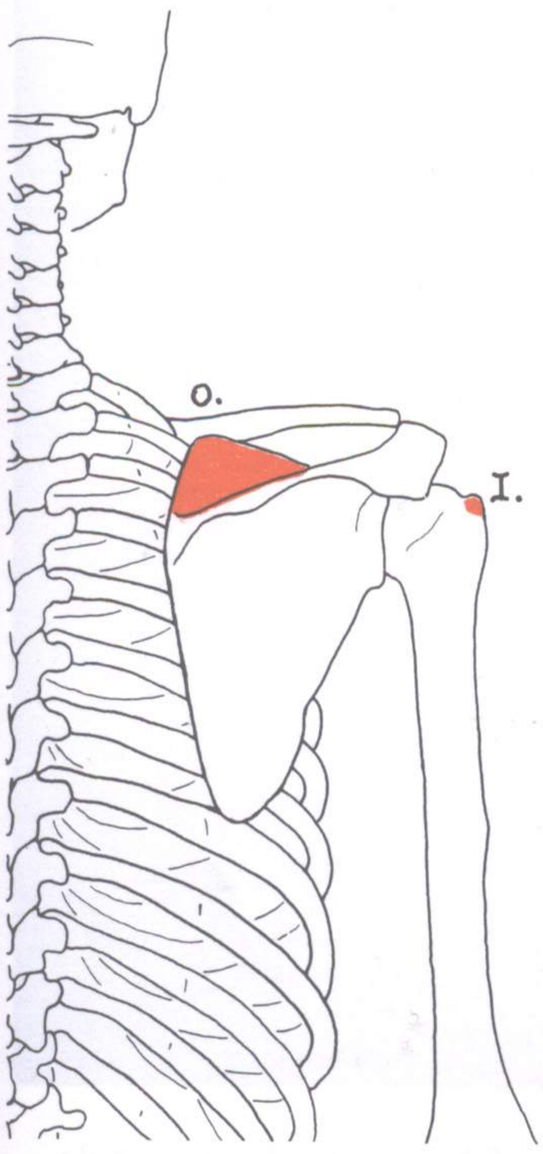
INSERTION Superior facet of the greater tubercle on the top of the lateral part of the proximal extremity of the humerus.

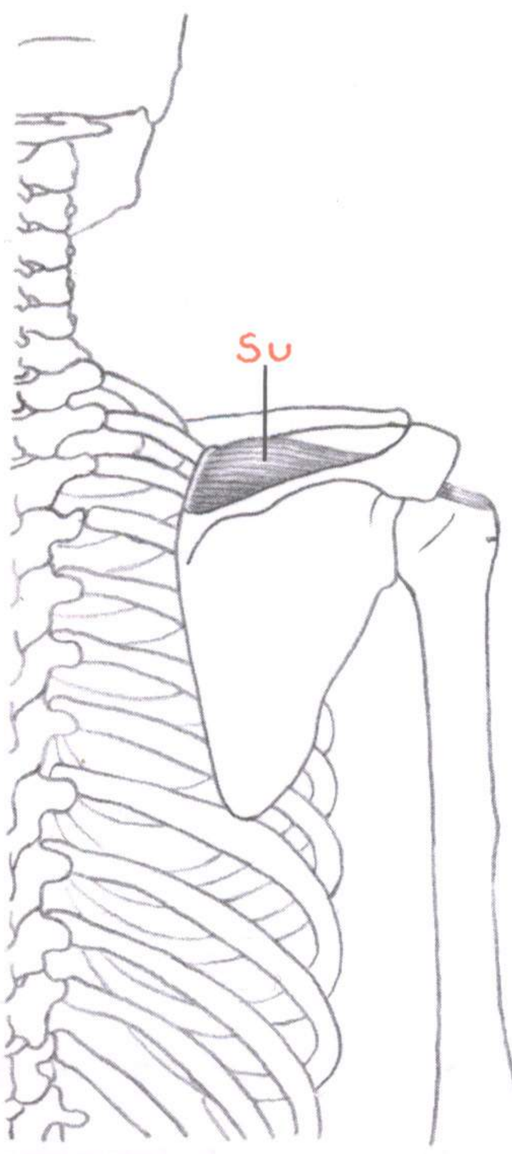
ACTION Abducts the arm; stabilizes the shoulder joint from above by pulling the head of the humerus into its socket.

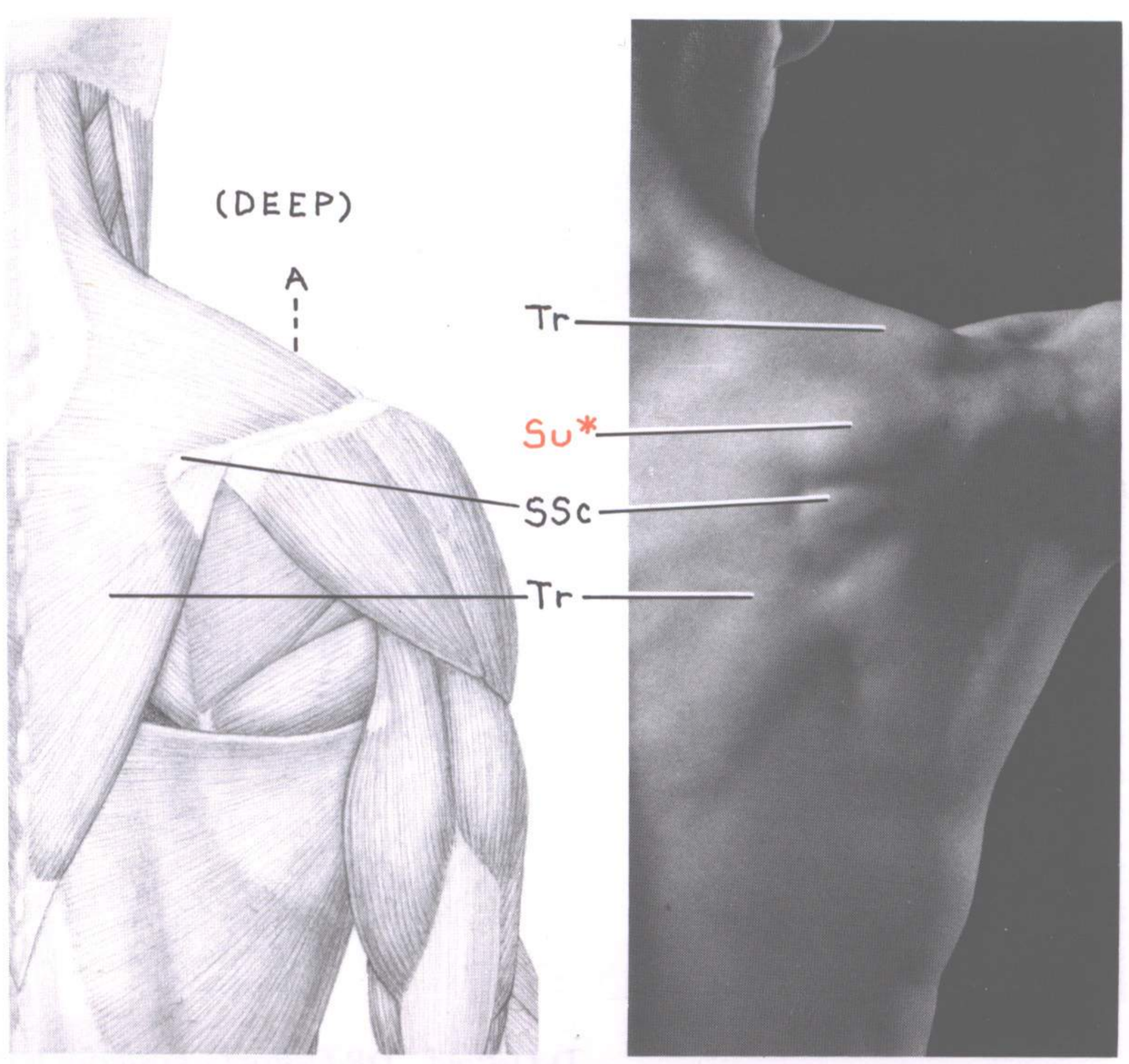
STRUCTURE The supraspinatus passes laterally over the top of the shoulder joint (under the acromion) to its insertion on the outside of the top of the proximal extremity of the humerus. Although it lies deep to the trapezius under a substantial thickness of muscle, when the arm is abducted, its form is occasionally revealed as a bulging egg-shaped or teardrop form (pointed end directly laterally) above the medial half of the spine of the scapula. In this position, the supraspinatus is at its shortest and thickest.

If the scapula is prevented from rotating (either by external resistance or internal muscle fixation) as the arm is abducted to the horizontal away from the side of the body, any bulge developing above the scapular spine must be the supraspinatus, since in this case there is no shortening of the trapezius.

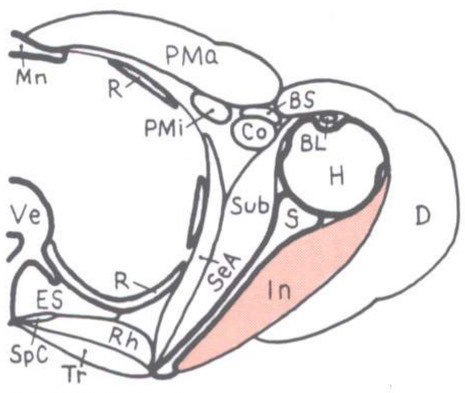
When the arm is down by the side of the body, there is no indication of the supraspinatus on the surface. A slight hollow may actually develop above the scapular spine, as the supraspinatus is now stretched thin.







Om *Omohyoid* **S** *Scapula* **SSc** *Spine of scapula* **Su** *Supraspinatus* **Tr** *Trapezius* * *Under trapezius*



Infraspinatus

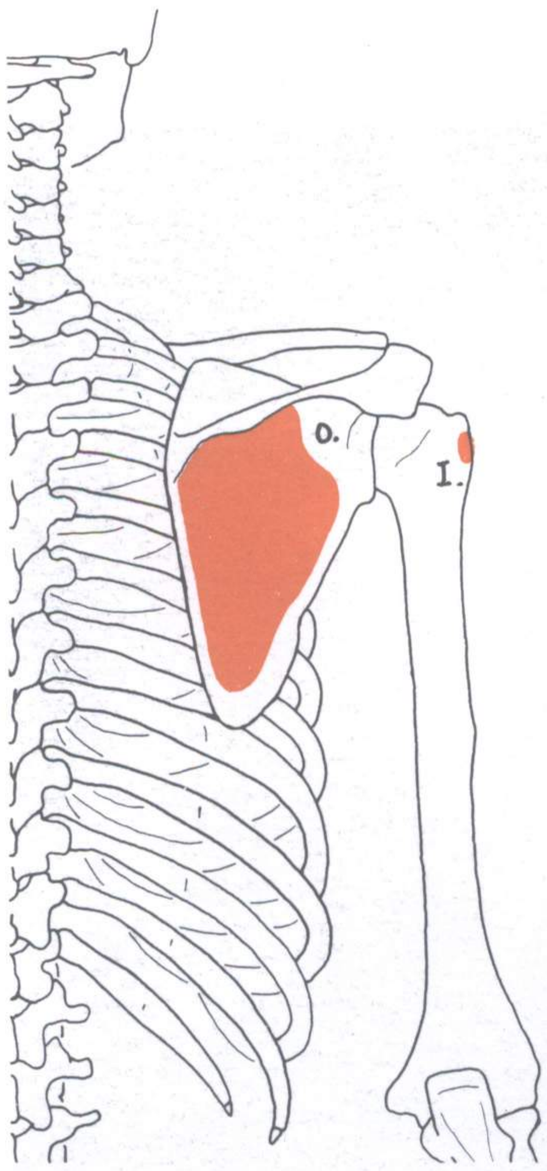
ORIGIN Most of the posterior surface of the scapula below the spine *(infraspinatus fossa)*.

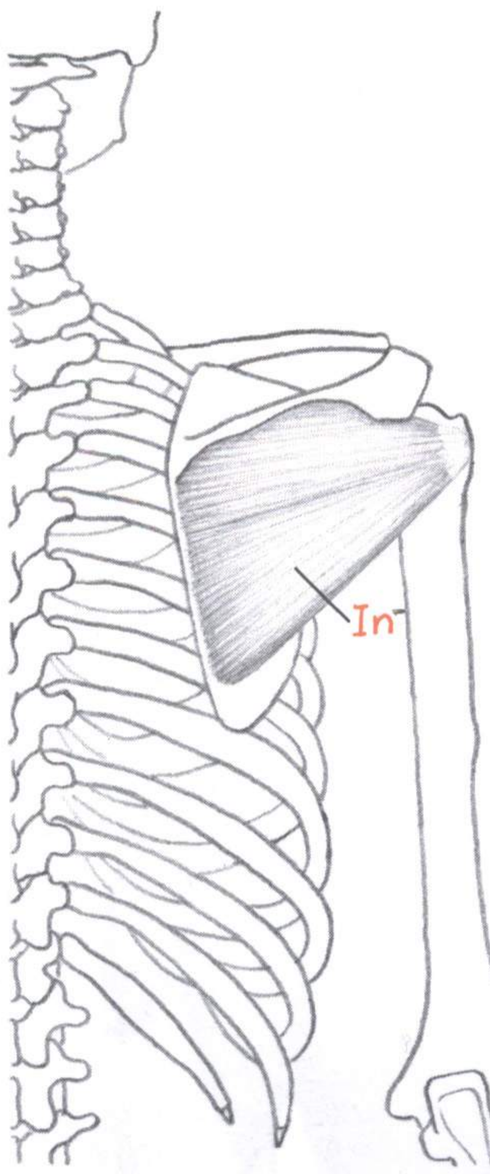
INSERTION Middle facet of the greater tubercle of the humerus.

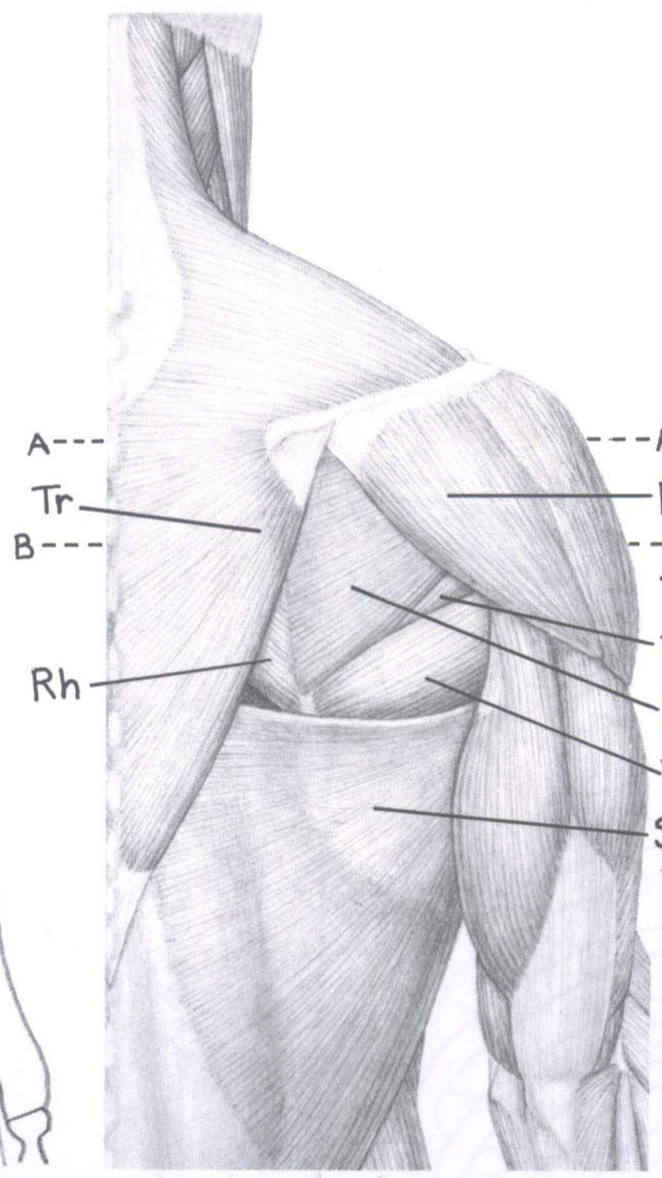
ACTION Laterally rotates the arm; helps stabilize the shoulder joint from behind by holding the head of the humerus in its socket.

STRUCTURE The infraspinatus is a flat triangular muscle that sits on the back of the shoulder blade below the spine. Although typically exhibiting a slightly planar surface surrounded by bulging muscles, the infraspinatus itself can bulge considerably when the humerus is laterally rotated to its maximum (this action shortens and thickens the muscle). Because its lateral portion is covered by the deltoid, the superficial area of the infraspinatus may appear as a wide vertical form when the arm is down. When the arm is raised, the posterior portion of the deltoid slides upward, exposing more surface area of the infraspinatus.

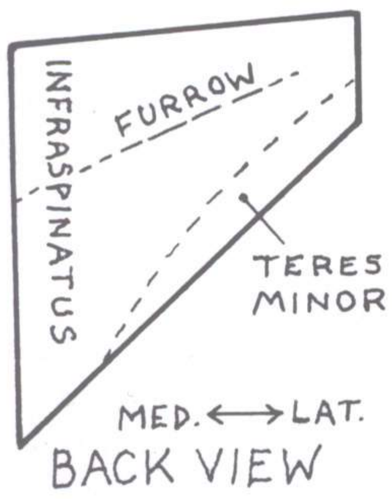
The muscle fibers, directed outward and upward, seem to be folded on themselves, which occasionally divides the infraspinatus into two forms—a superior and an inferior—separated by a shallow furrow that is directed outward and upward toward the head of the humerus. This furrow may or may not reach all the way over to the medial border of the scapula.







D *Deltoid* **DP** *Deltoid—posterior portion* **H** *Humerus* **In** *Infraspinatus* **Rh** *Rhomboids* **S** *Scapula* **SeA** *Serratus anterior* **SSc** *Spine of scapula* **TLo** *Triceps—long head* **TMa** *Teres major*



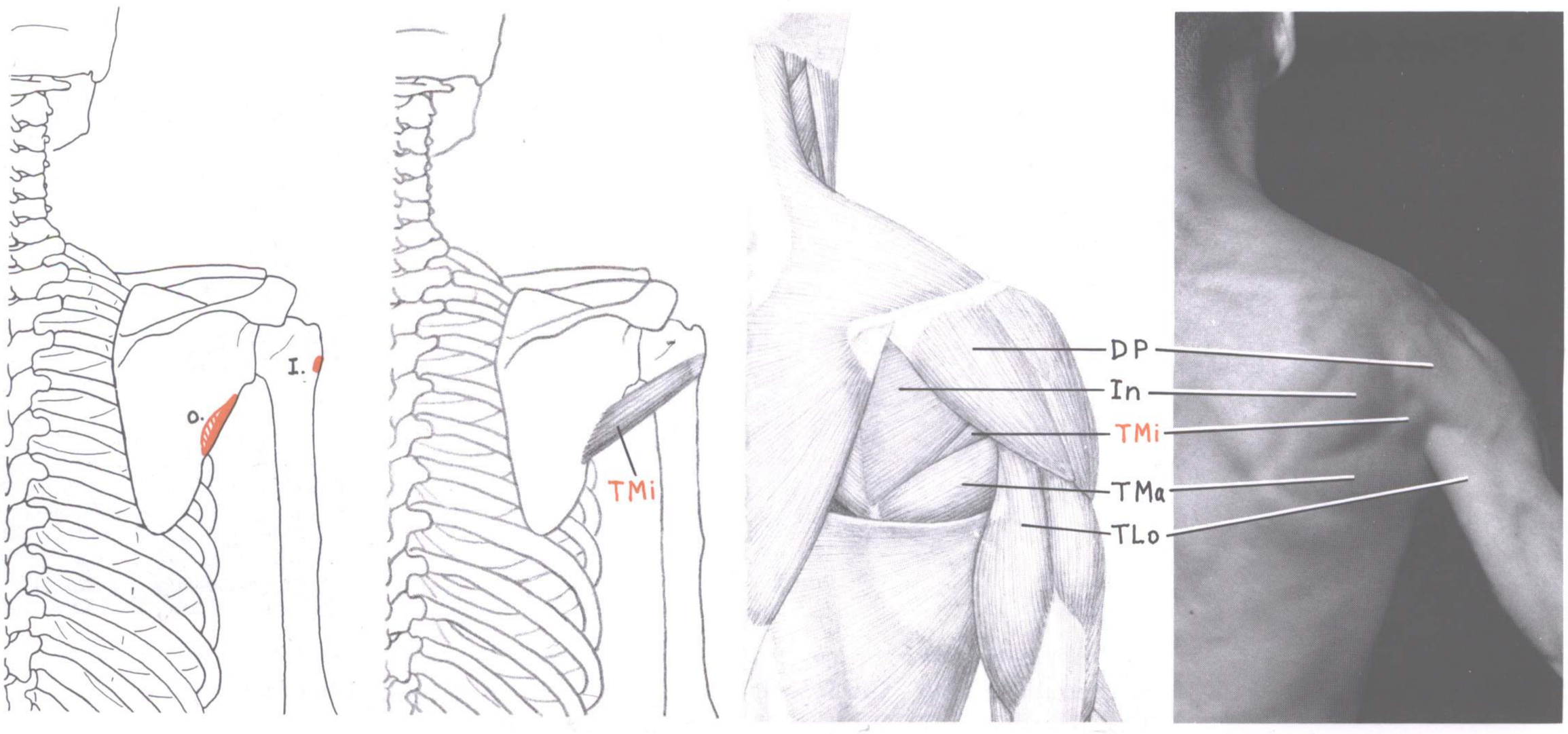
Teres Minor

ORIGIN Raised ridge of bone on the posterior surface of the upper two-thirds of the lateral (axillary) border of the scapula, and partly from the fascia covering the posterior surface of the infraspinatus and the deep surface of the medial end of the teres major.

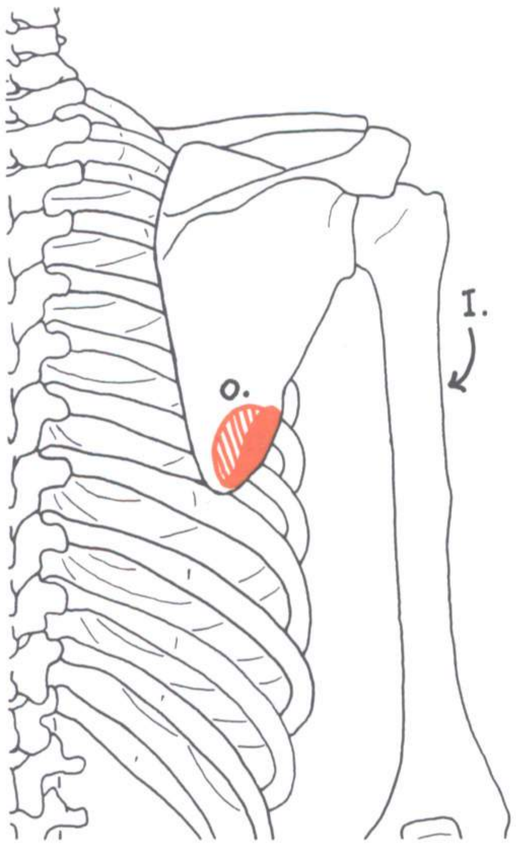
INSERTION The lowest of the three facets of the greater tubercle of the humerus and a short distance immediately below it on the shaft.

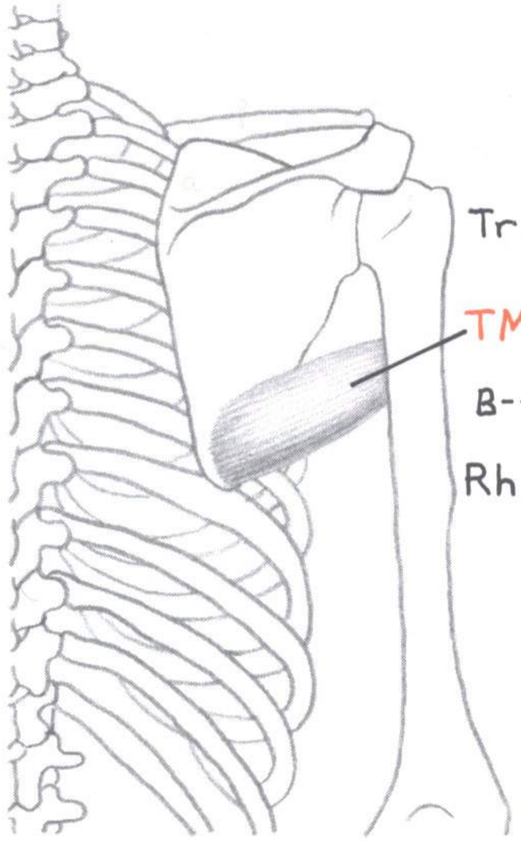
ACTION Laterally rotates the arm and weakly adducts it; helps stabilize the shoulder joint by holding the head of the humerus in its socket.

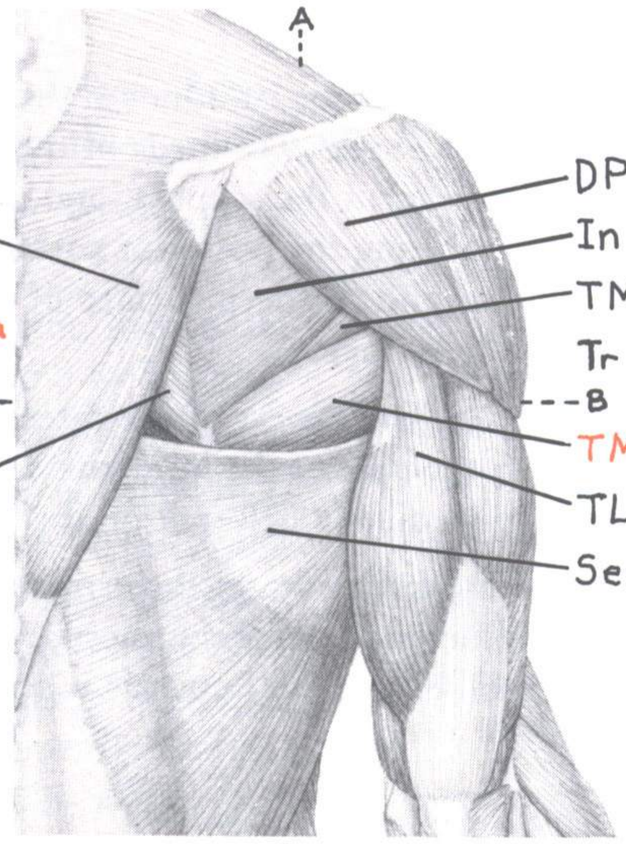
STRUCTURE Rarely seen on the surface, the teres minor is a small, elongated, cylindrical muscle that usually blends with the plane created by the infraspinatus muscle. Both muscles are covered by a layer of dense fascia which consolidates their forms. The teres minor runs obliquely upward and outward from its origin and inserts via a thick, flat tendon onto the back of the superior part of the humerus. It is occasionally seen when the arm is held horizontally, laterally rotated, and then pushed downward and backward against resistance.

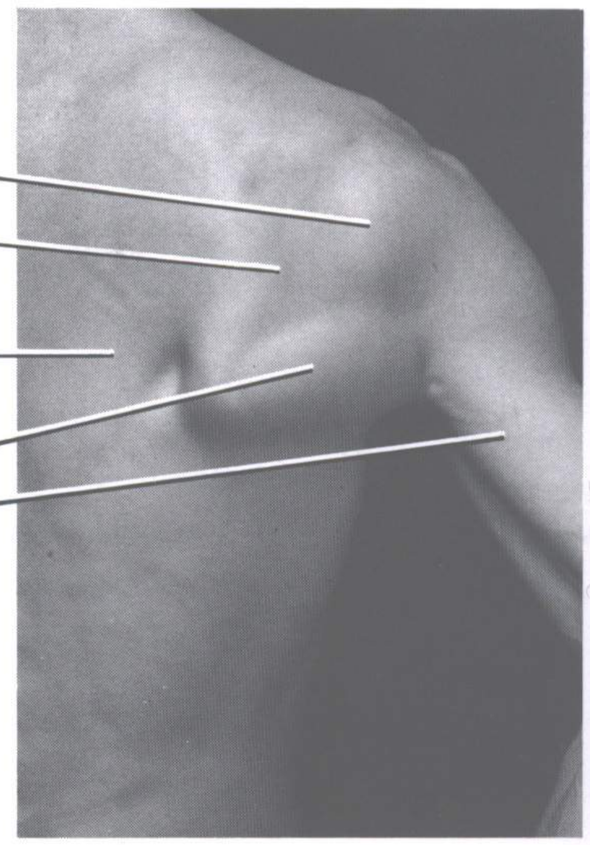


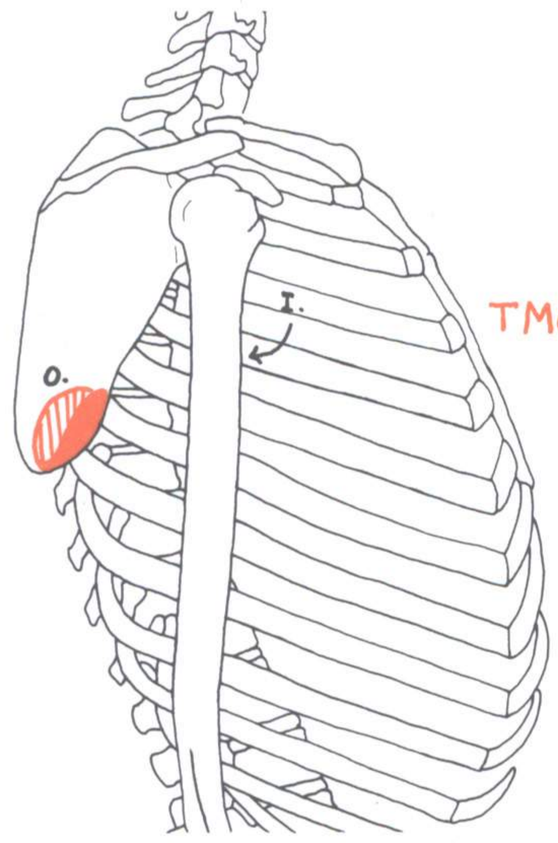
TMi *Teres minor* **Tr** *Trapezius* * *Under latissimus dorsi*

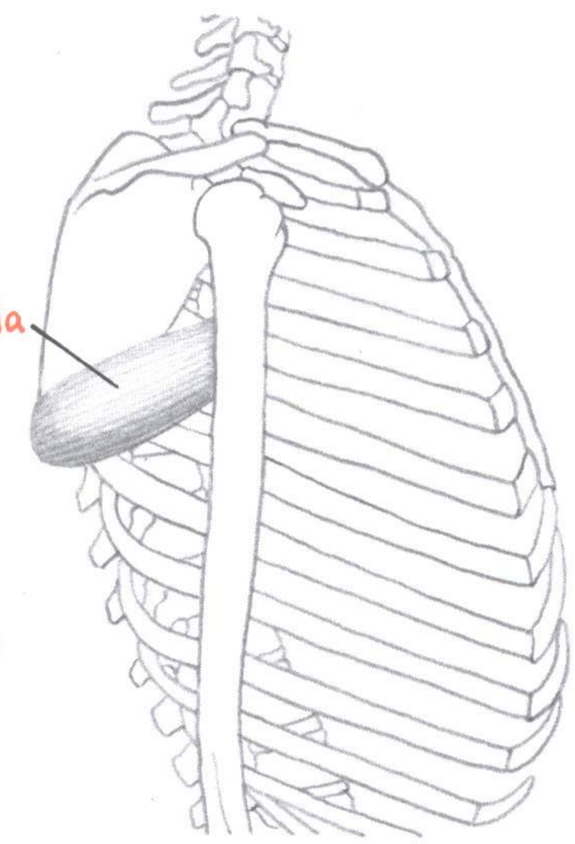


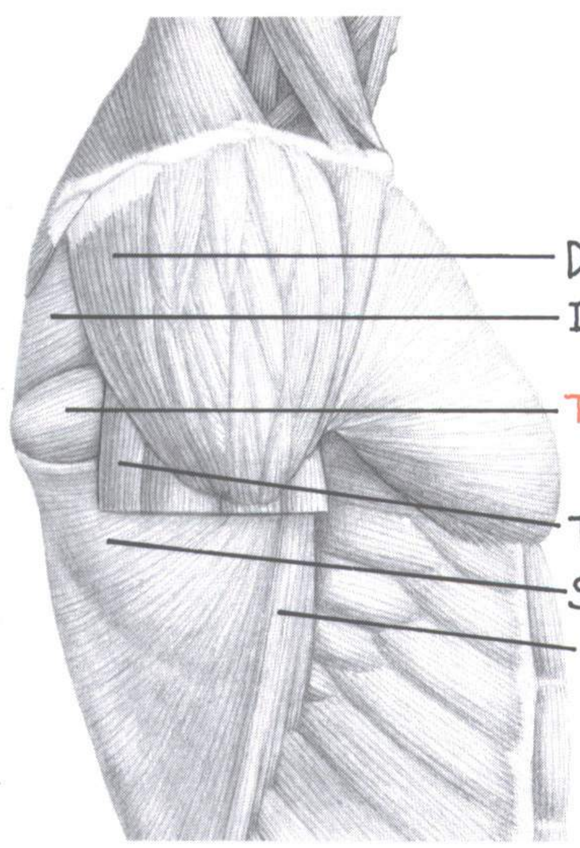


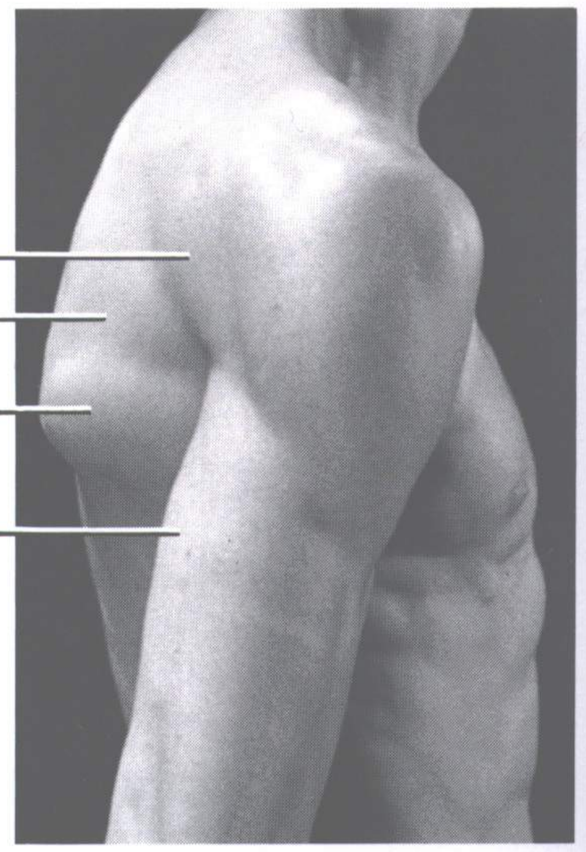


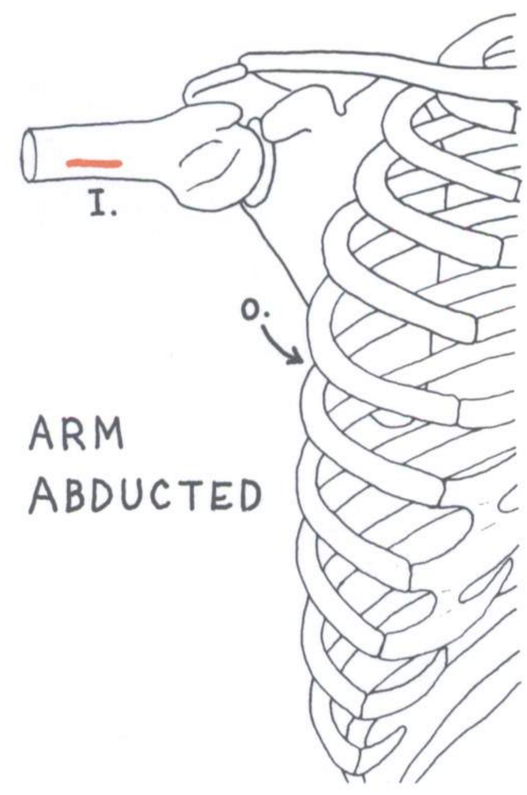


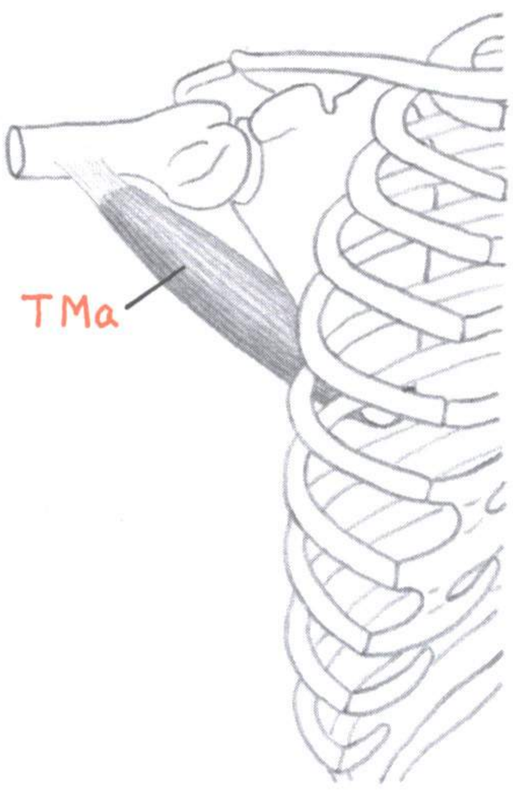


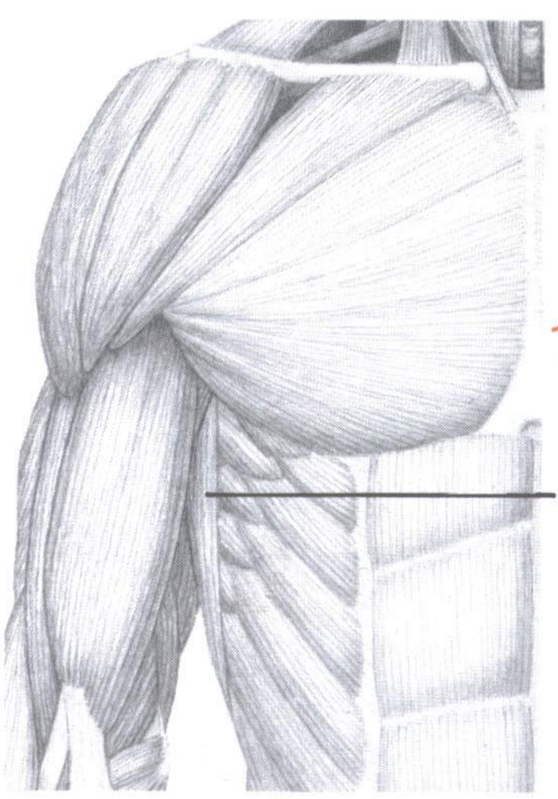


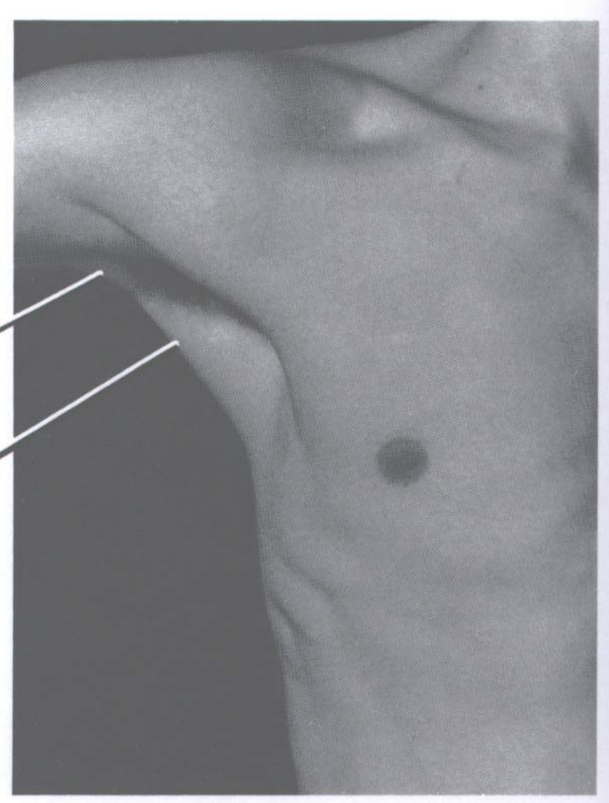




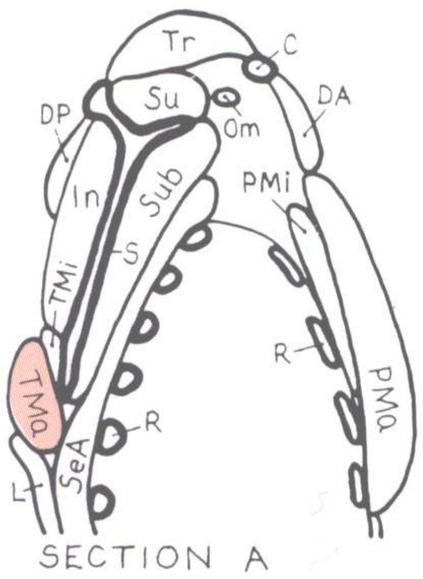




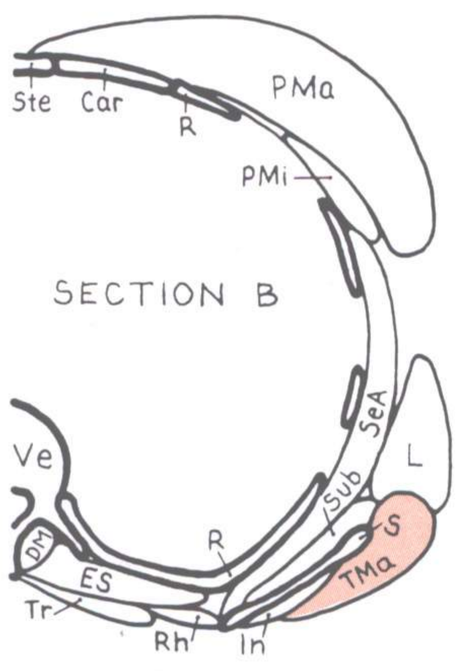




DP *Deltoid—posterior portion* **In** *Infraspinatus* **L** *Latissimus dorsi* **Rh** *Rhomboids* **S** *Scapula*
SeA *Serratus anterior* **Sub** *Subscapularis* **TLo** *Triceps—long head* **TMa** *Teres major*
TMi *Teres minor* **Tr** *Trapezius* * *Under latissimus dorsi*



SECTION A



Teres Major

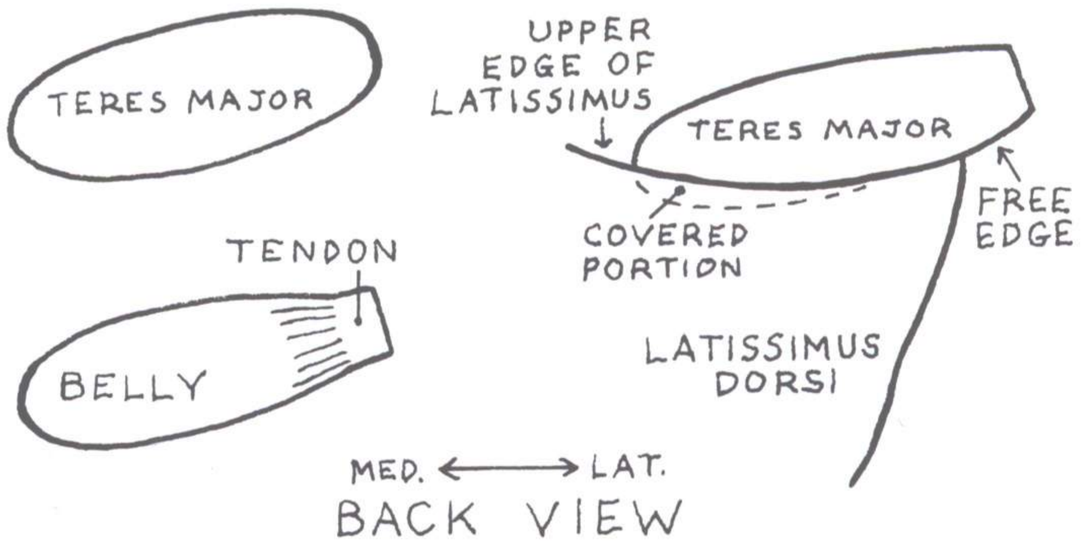
ORIGIN Raised oval area on the posterior surface of the inferior angle of the scapula (excluding a narrow vertical area immediately adjacent to the medial border), continuing one-third of the way up its lateral border, and partly from the adjacent fascia covering the outer surface of the infraspinatus and teres minor muscles.

INSERTION A short vertical line on the medial lip of the bicipital groove (intertubercular sulcus) on the inside front corner of the humerus, one-fourth of the way down the humerus (medial to and slightly lower than the insertion of the latissimus dorsi).

ACTION Adducts and medially rotates the arm; extends the flexed arm. Note: the teres major and minor both adduct the arm, but are antagonists for rotation of the humerus—the major rotates it medially; the minor, laterally.

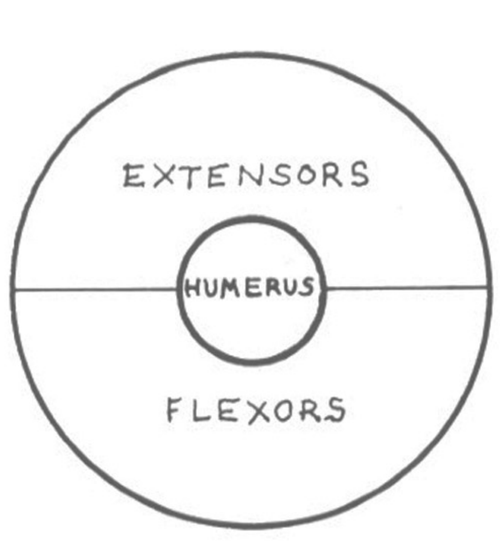
STRUCTURE The teres major is a cylindrical, but somewhat flattened, thick, bulging muscle. Laterally, it flattens into a broad tendon as it inserts. The medial end of the belly does not quite reach the medial border of the scapula. The teres major creates part of the posterior wall of the armpit, crossing from the bottom of the back of the shoulder (bottom of the scapula) to the *inside front corner* of the arm. Diving into the armpit, its axis is directed outward, upward, and forward. When the arm lies against the body and the teres major is tensed, the belly is shortened, becoming oval and bulged (the infraspinatus and teres minor are flattened and planar). In this position, the teres major may not appear to be directed toward the inner front corner of the humerus, but it ultimately is. In the raised arm position, the stretched teres major becomes noticeably longer and thinner, and the upper edge of the latissimus dorsi can often be seen as a raised relief lying across its belly. The latissimus covers the lower medial portion of the teres major.

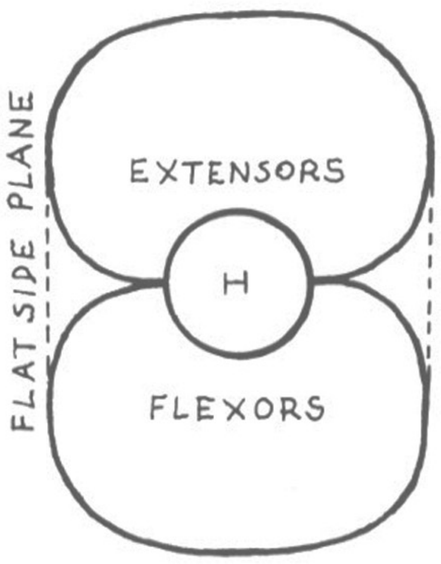
Because the teres major inserts lower (distal) onto the humerus than does the latissimus, the cylindrical form of the teres major can be seen as it leaves the sling of latissimus, giving the posterior wall of the armpit a double convex curve—the teres major is seen closer to the arm (lateral and higher) and latissimus closer to the body (medial and lower). This is best seen when the arm is held horizontal out to the side of the body (see Latissimus Dorsi).

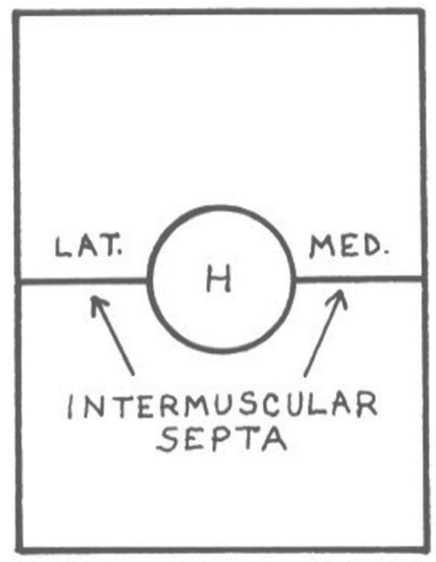


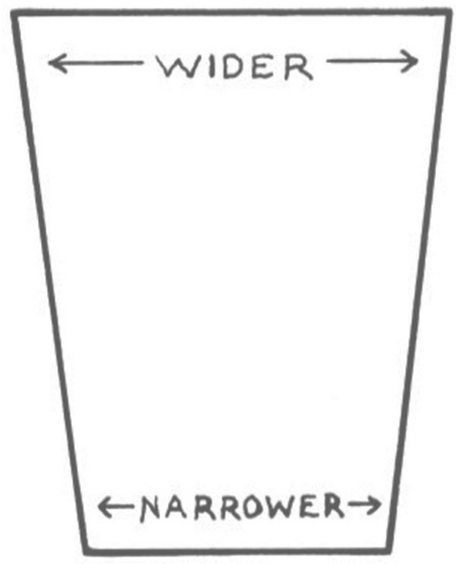
BACK VIEW

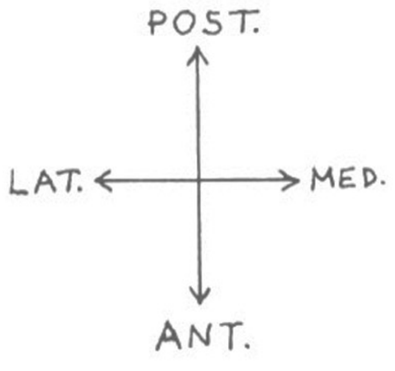
The Upper Arm Muscles

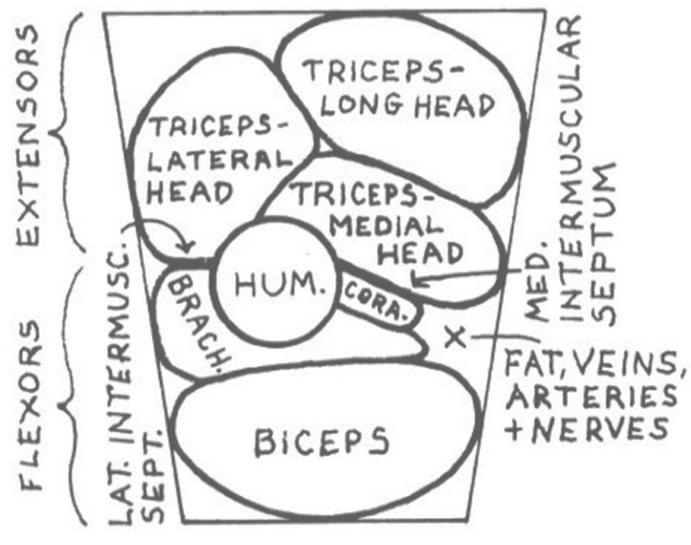




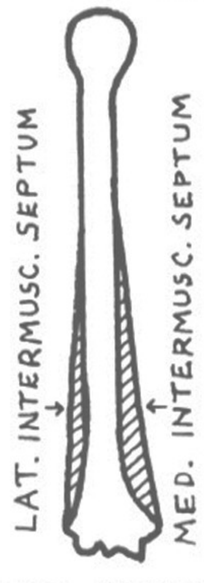








CROSS SECTIONS (MID ARM)



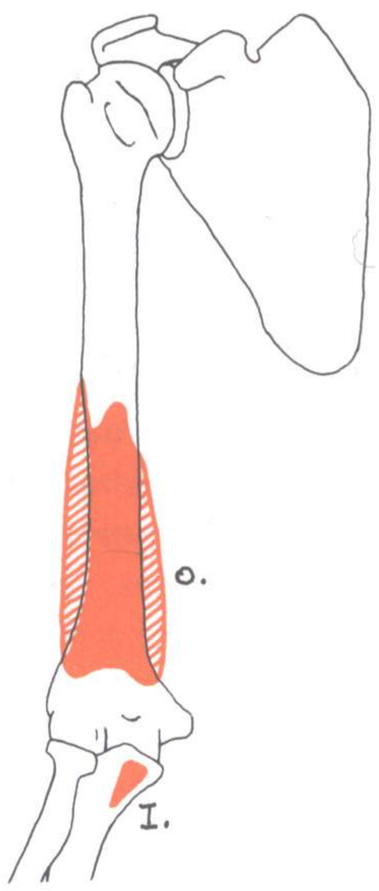
RIGHT HUMERUS
FRONT VIEW

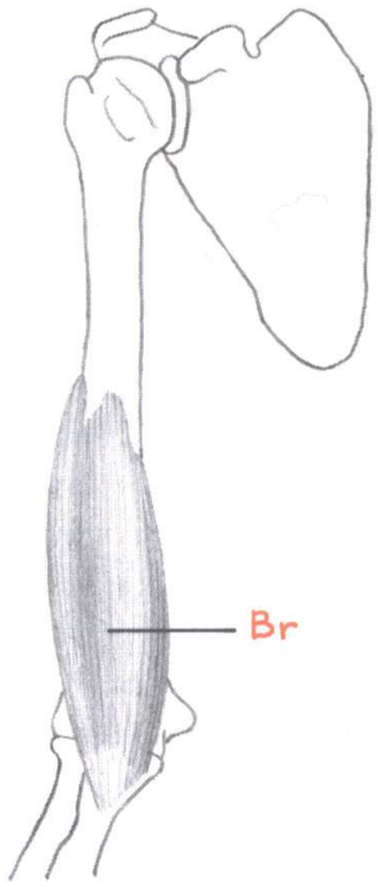
The Upper Arm Muscles

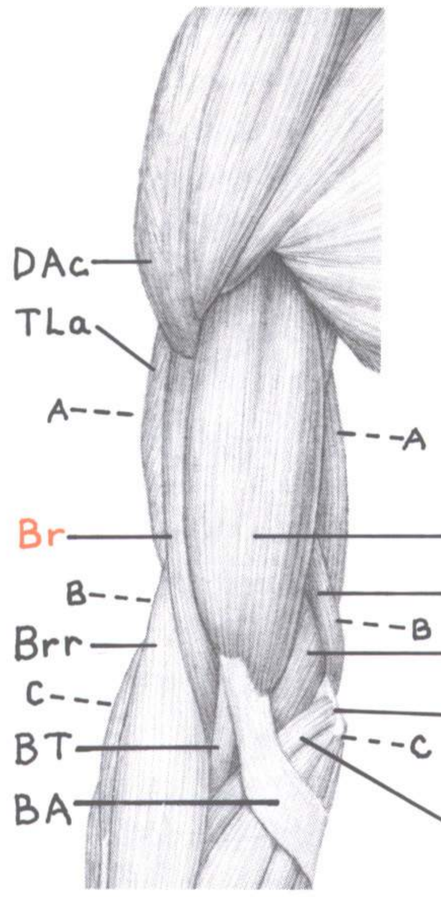
The *UPPER ARM,* or brachium, can be visualized as an elongated, rectangular solid, flattened from side to side. The flatness and planar quality of the sides are characteristic of the upper arm; this is caused by the flexor muscles in front (biceps, brachialis, and coracobrachialis) and the extensor muscle in back (the three heads of the triceps) bulging considerably, which automatically creates the flattened side planes. The sides converge anteriorly (the biceps is narrower than the triceps). The upper arm is thicker from front to back than from side to side. The front and back surfaces are rounded by the biceps and triceps muscles, respectively.

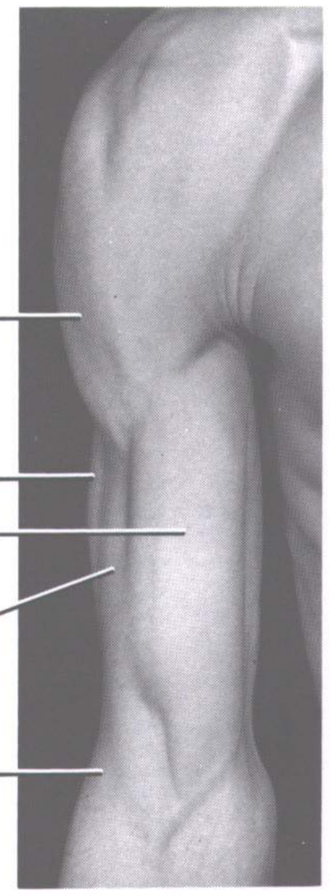
Coming off each side of the length of the humerus are narrow, sheetlike, **intermuscular septa**—a medial and a lateral. They act as partitions, separating the flexors in front from the extensors in back. Their purpose is to provide additional surface for muscle origin—the brachioradialis and extensor carpi radialis longus from the front of the lateral intermuscular septum; the lateral head of the triceps from the back of the lateral intermuscular septum; the brachialis from the front of both septa; and the medial head of the triceps from the back of both septa. The effects on the surface caused by the septa are described under the medial and lateral heads of the triceps.

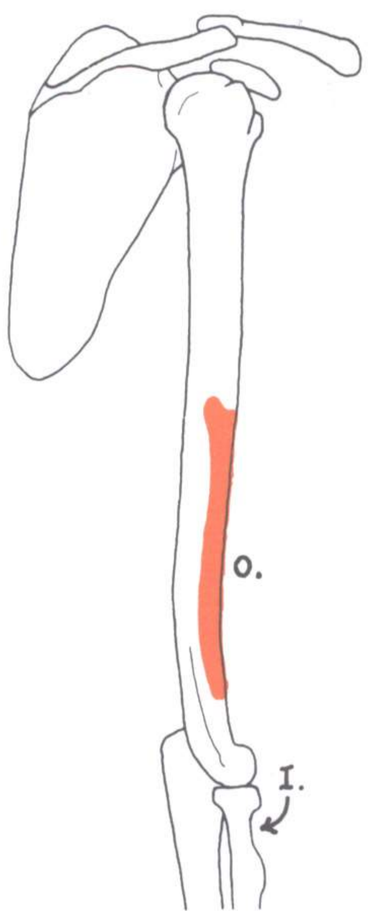
The **neurovascular bundle** passes down the center of the medial aspect of the upper arm, between the flexor and extensor muscles. It consists of nerves, arteries, and veins which emerge from the armpit and disappear into the medial side of the front of the elbow. These structures, along with the fat that surrounds and protects them, fill the furrow between the flexors and extensors. The neurovascular bundle is occasionally directly seen on the inside of the upper half of the upper arm, as a cordlike relief situated between the coracobrachialis and the long head of the triceps.

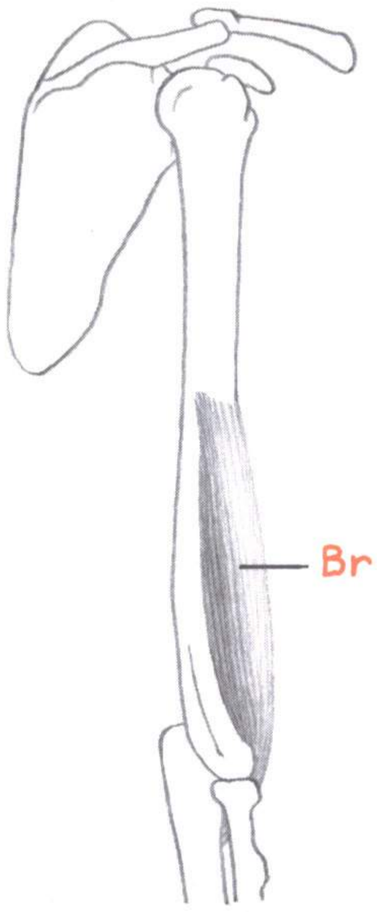


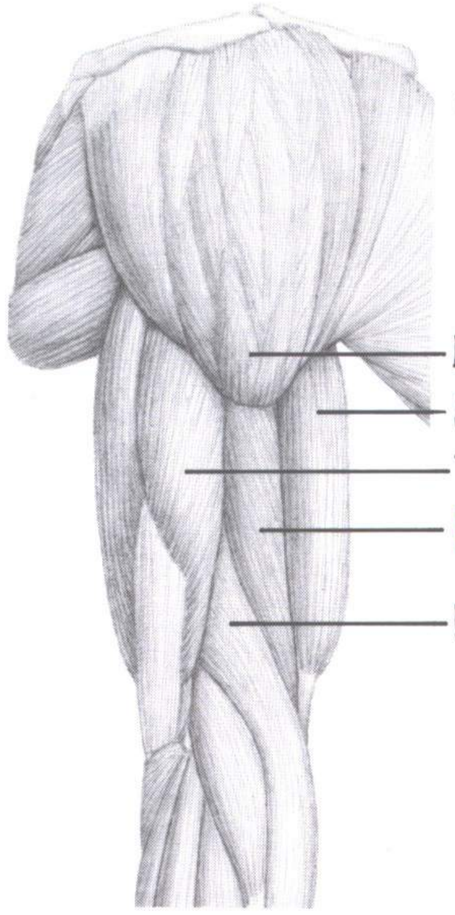


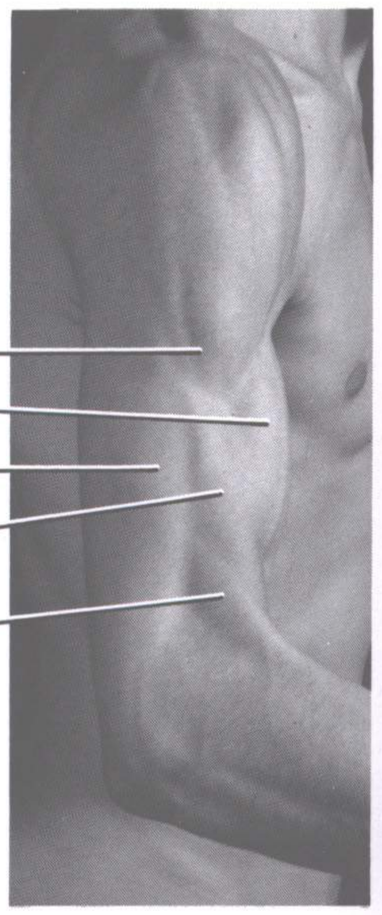


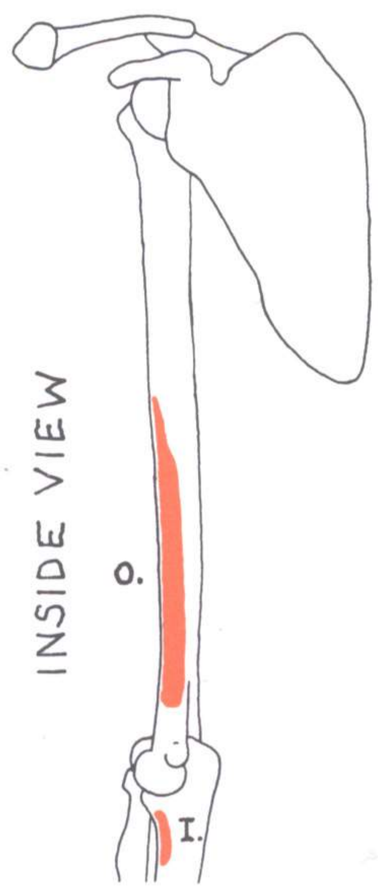


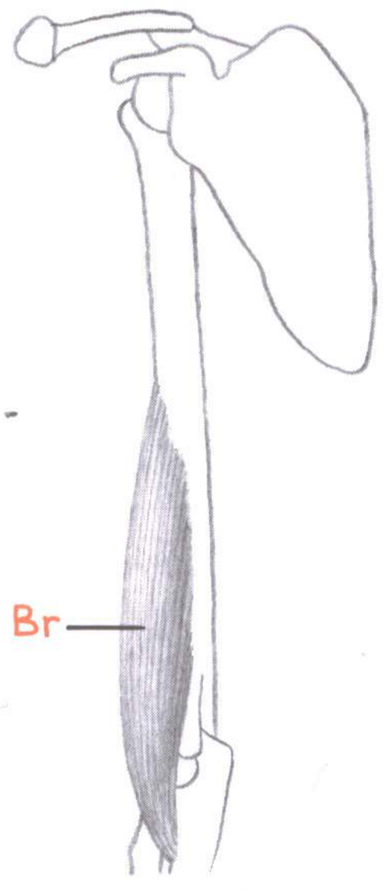


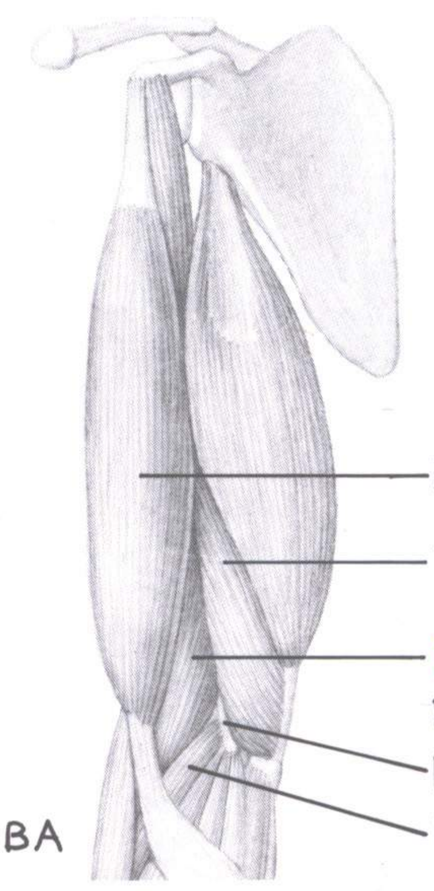


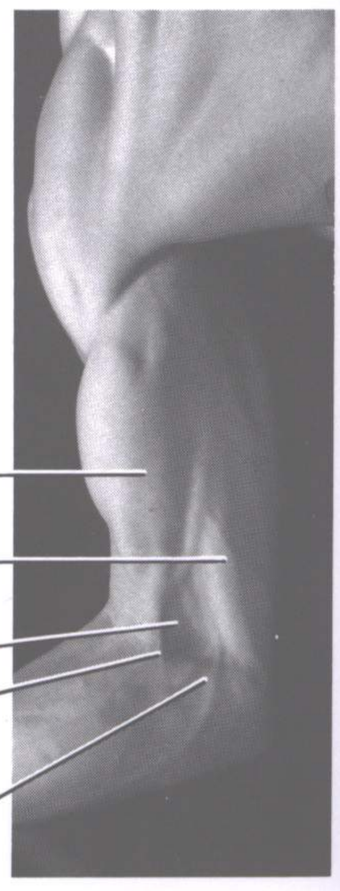




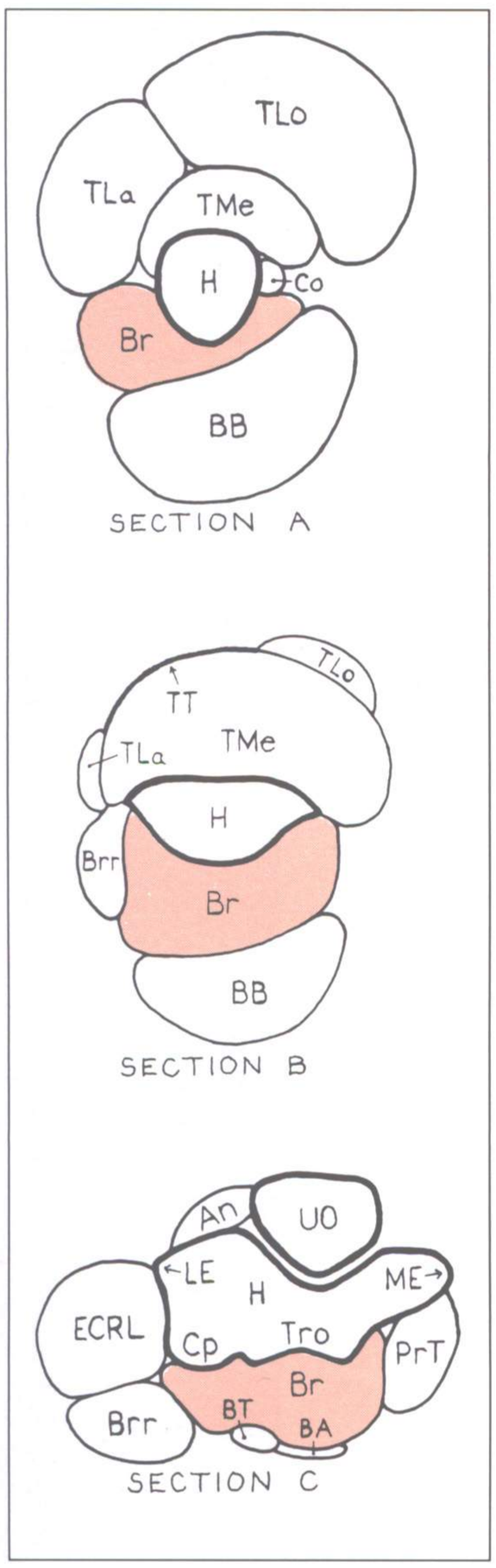








BA *Bicipital aponeurosis* **BB** *Biceps brachii* **Br** *Brachialis* **Brr** *Brachioradialis* **BT** *Biceps tendon*
Co *Coracobrachialis* **Cp** *Capitulum* **DAc** *Deltoid—acromial portion* **H** *Humerus*
MIS *Medial intermuscular septum* **PrT** *Pronator teres* **TLa** *Triceps—lateral head*
TMe *Triceps—medial head* **Tro** *Trochlea*



Brachialis

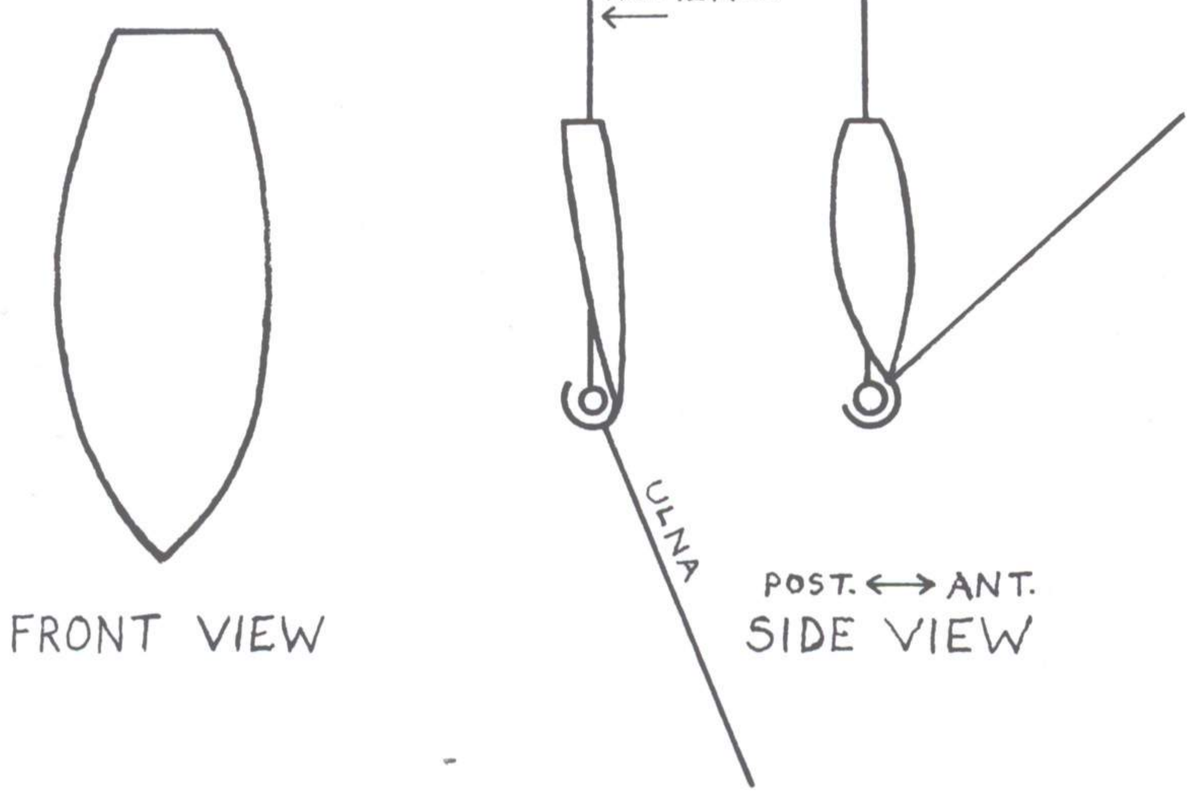
ORIGIN Lower half of the anterior surface of the shaft of the humerus (the upper end of the origin continues around to the lateral side of the bone, embracing the insertion of deltoid), and from both the lateral and medial intermuscular septa.

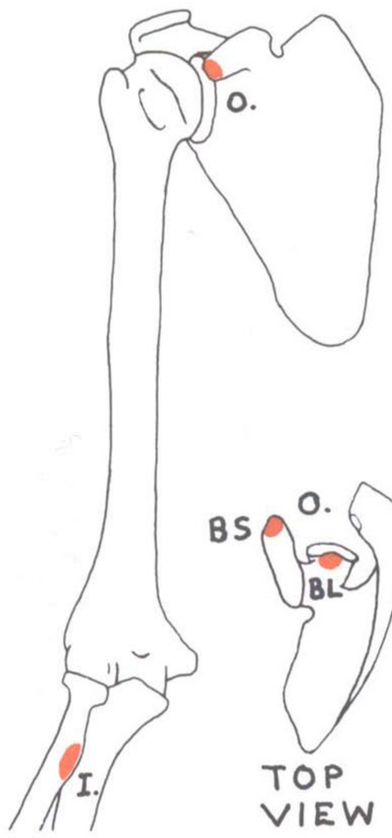
INSERTION Anterior surface of the coronoid process of the ulna.

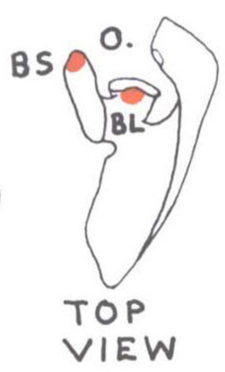
ACTION Flexes the forearm.

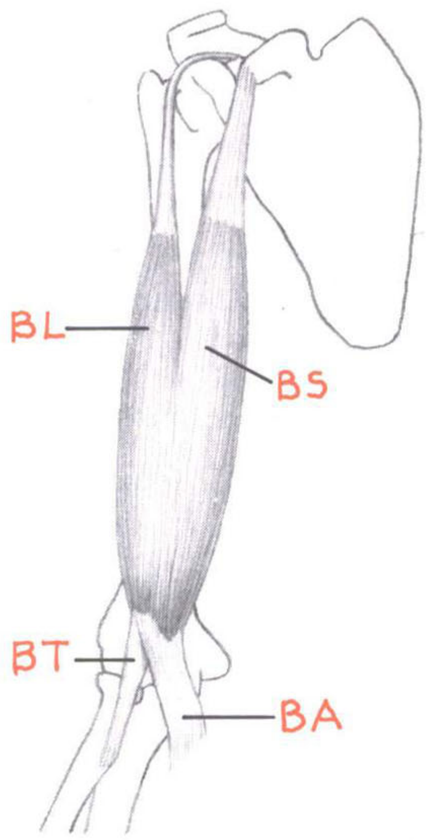
STRUCTURE Lying under the biceps and in front of the elbow joint, this relatively wide, fleshy muscle is seen only on the outside of the upper arm. The narrow visible portion passes obliquely downward and forward, first between the biceps and triceps and then between the biceps and brachioradialis. Its obliquity increases as the elbow is flexed; it also becomes shorter and rounder during elbow flexion, appearing as an oval relief on the outside of the arm at full flexion. The brachialis lies on and adds muscular fullness to the front of the lower half of the humerus. Its front surface is somewhat flattened to receive the flattened posterior surface of the biceps. The fibers at the upper outer end of the brachialis blend directly with some of the inserting fibers of the deltoid. A depression may appear at this fusion.

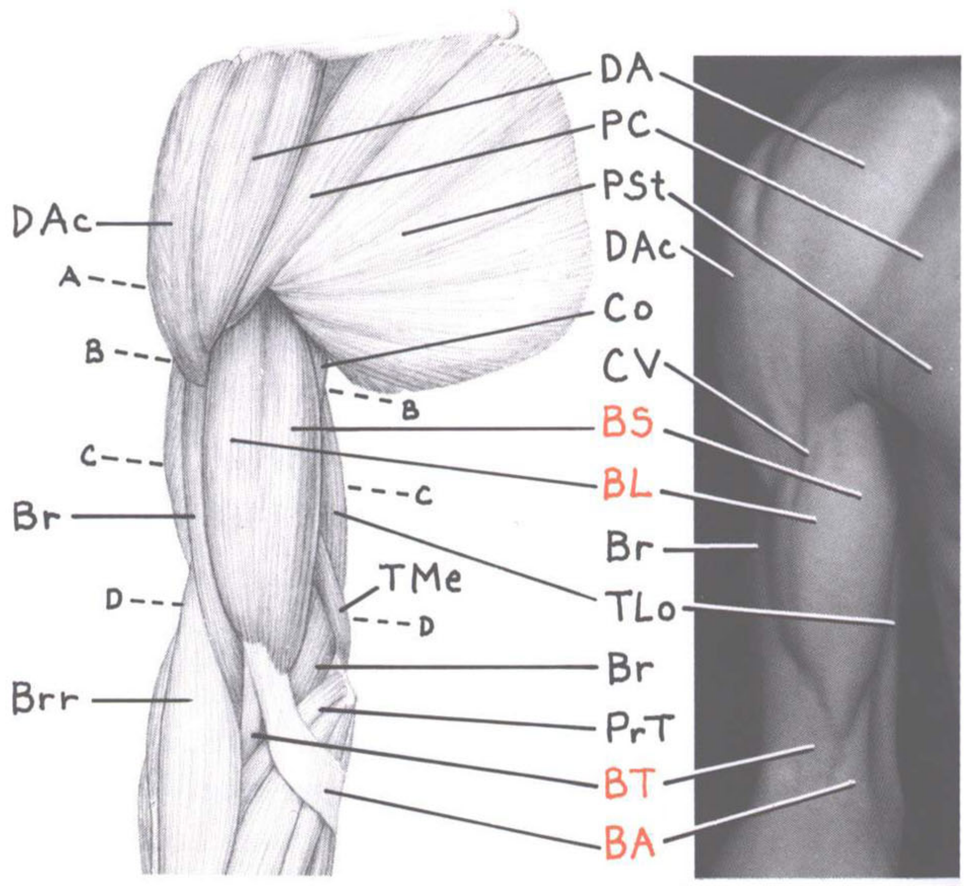
On the inside of the arm, the brachialis is concealed by nerves, arteries, veins, and especially fat. When the elbow is partially flexed and the muscles tensed, this area appears as a flat plane, bordered in front by the biceps and the raised medial edge of the bicipital aponeurosis and behind by the medial head of the triceps. The brachialis may occasionally be seen in this area as a recessed bulge, but it is always covered by blood vessels and fat that protects these vessels. When the elbow is fully extended, this portion of the brachialis is pushed forward at the elbow joint by the underlying trochlea of the humerus. It is still not seen independently; however, this area becomes fuller as it is pushed forward.

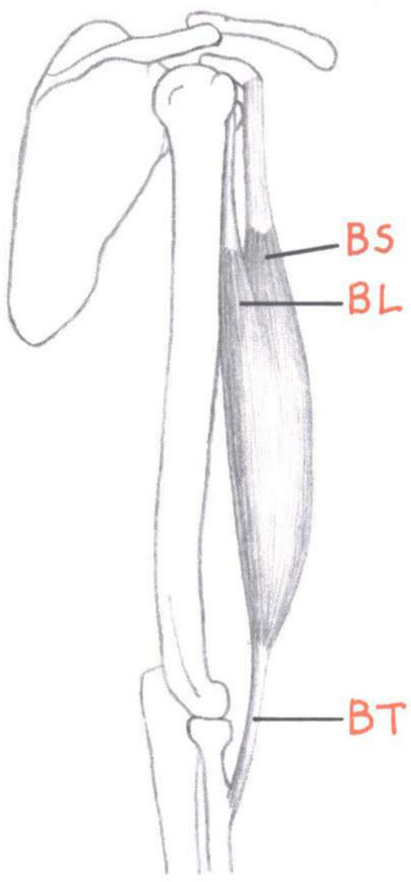


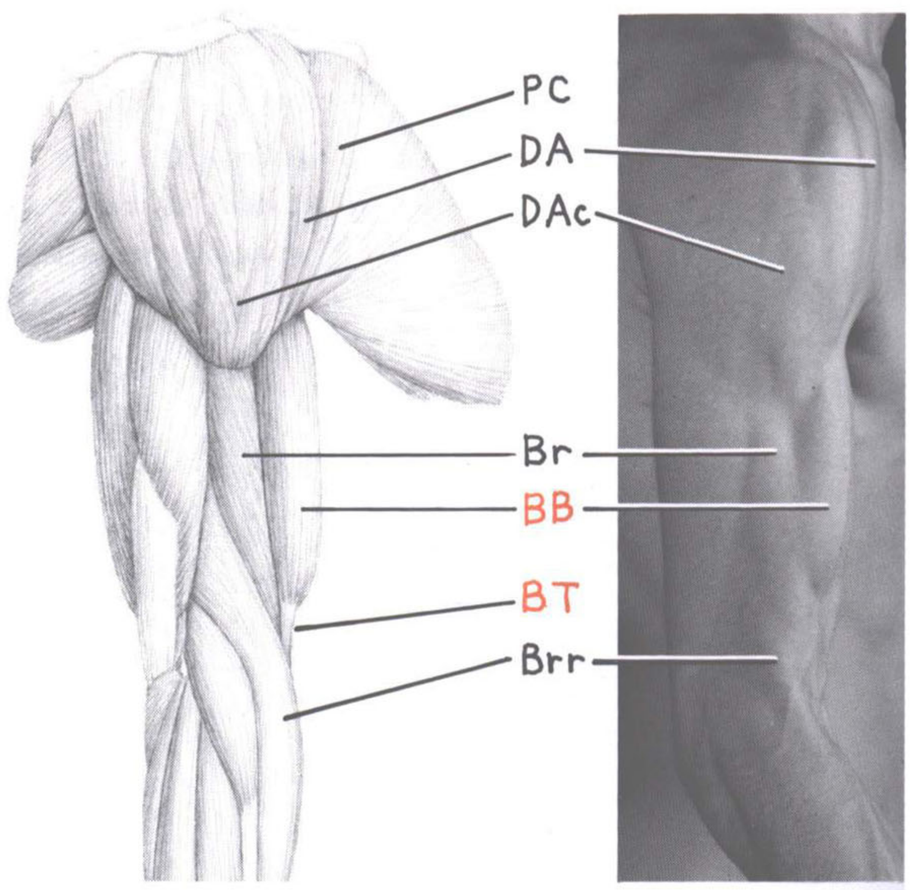


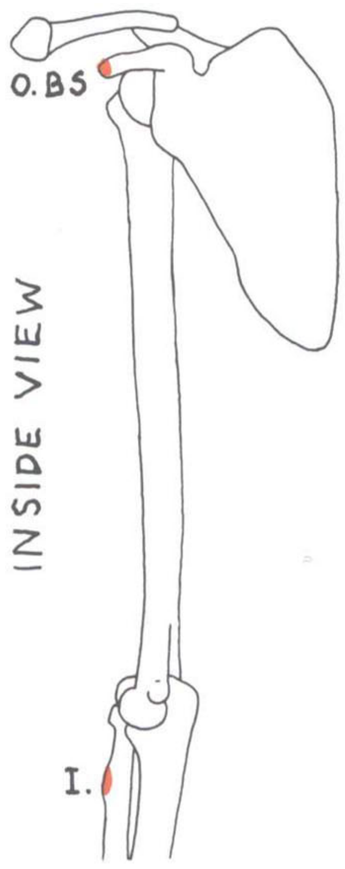


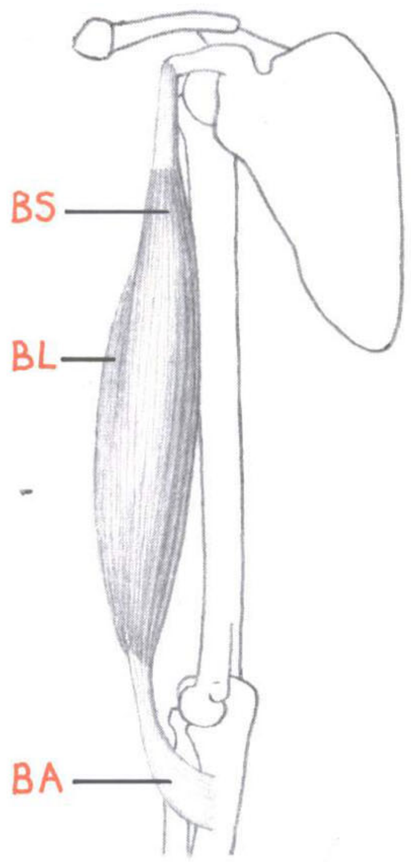


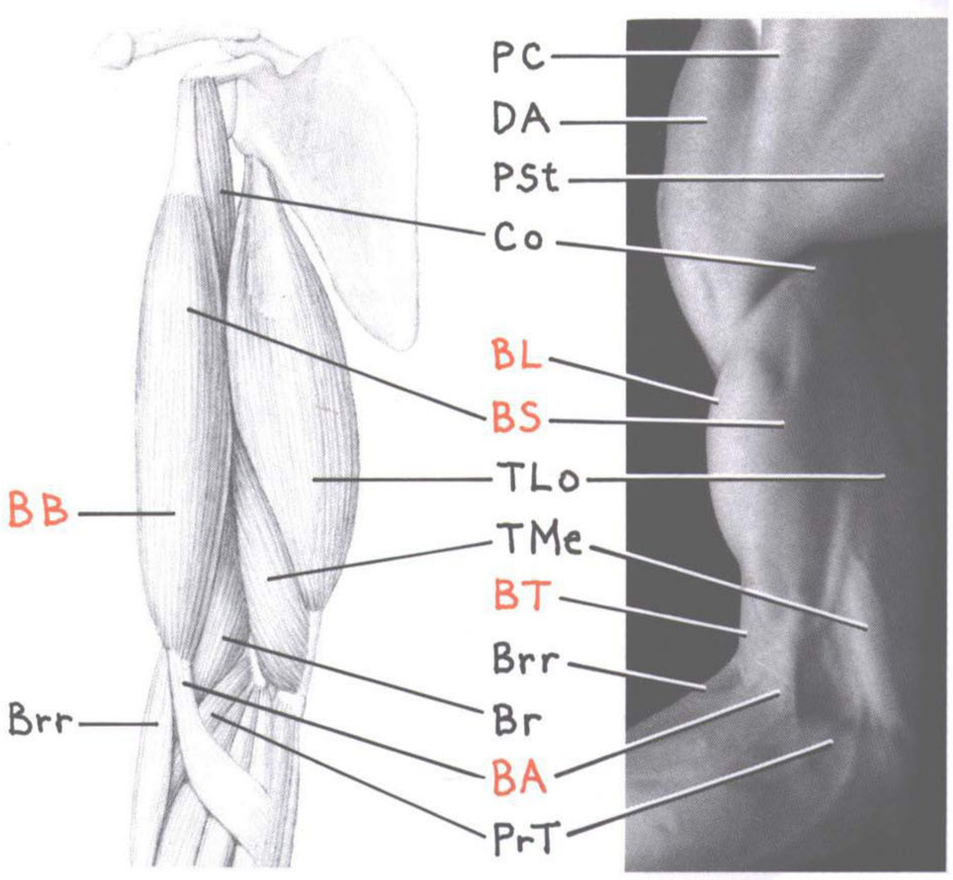




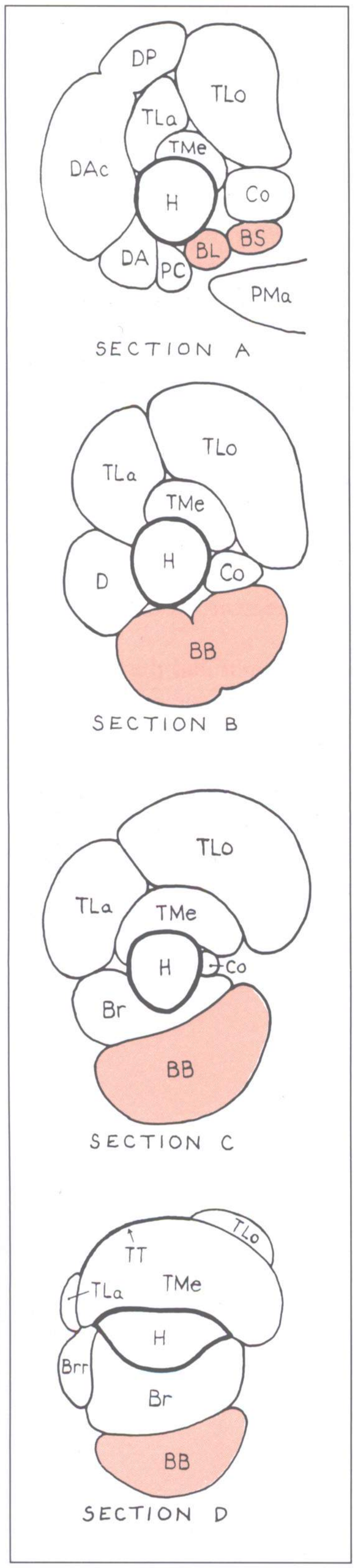








BA *Bicipital aponeurosis* **BB** *Biceps brachii* **BL** *Biceps brachii—long head* **Br** *Brachialis*
Brr *Brachioradialis* **BS** *Biceps brachii—short head* **BT** *Biceps tendon* **Co** *Coracobrachialis*
CV *Cephalic vein* **D** *Deltoid* **DA** *Deltoid—anterior portion* **DAc** *Deltoid—acromial portion*
H *Humerus* **PC** *Pectoralis—clavicular portion* **PMa** *Pectoralis major* **PrT** *Pronator teres*
PSt *Pectoralis—sternocostal portion* **TLo** *Triceps—long head* **TMe** *Triceps—medial head*



Biceps Brachii

ORIGIN *Long head:* Supraglenoid tubercle on the top of the glenoid fossa (socket) of the scapula. *Short head:* Tip of the coracoid process of the scapula (in common with the coracobrachialis).

INSERTION Tuberosity of the radius. The biceps has no attachment to the humerus—it has two origins from the scapula and one insertion into the radius.

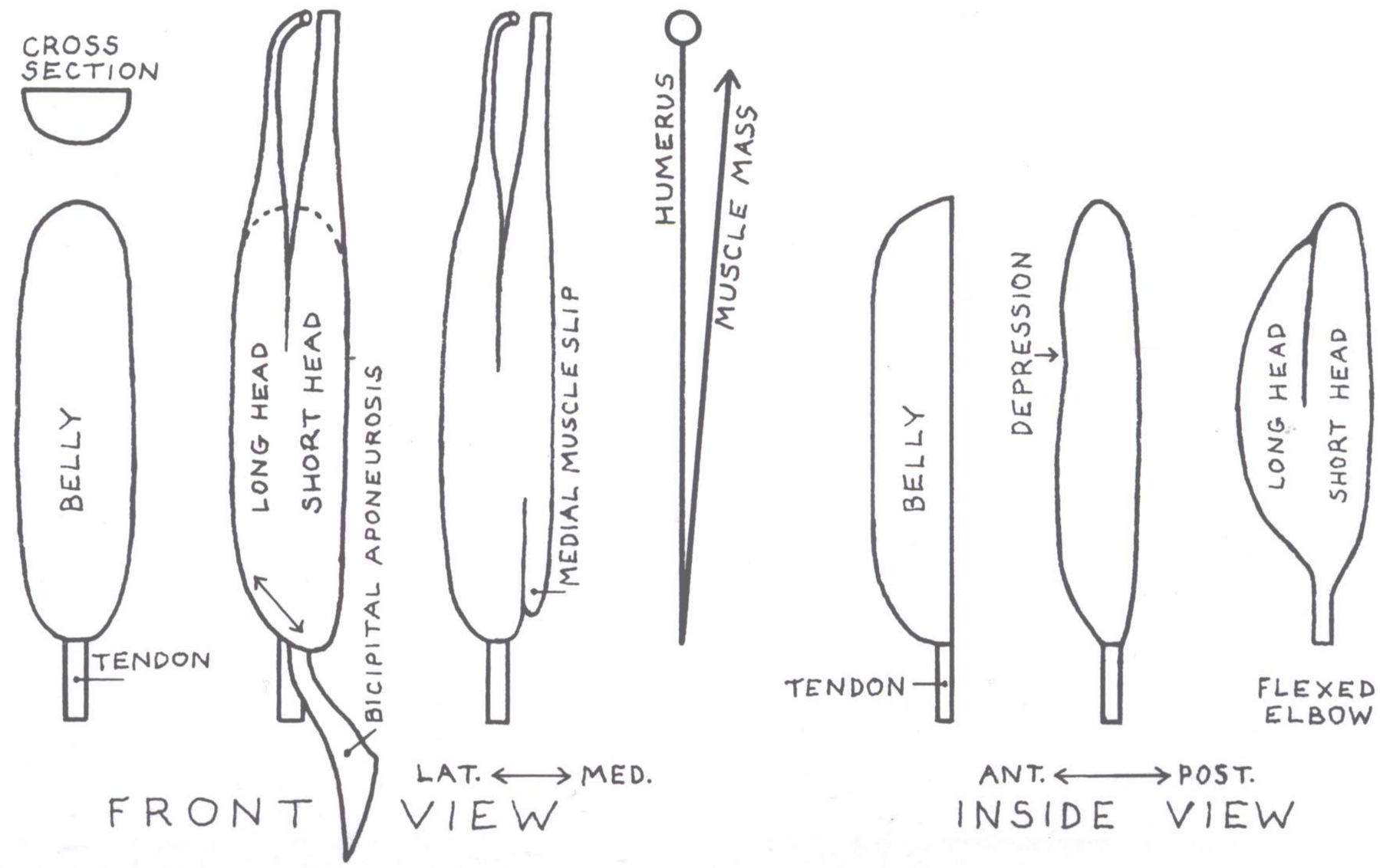
ACTION Flexes and/or supinates the forearm. Supination is most powerful when the forearm has been flexed to 90°. It also assists in flexing the arm in front of the body at the shoulder joint. The long head holds the head of the humerus in its socket, which also keeps the head away from the acromion when the arm is abducted.

STRUCTURE The fusiform fleshy belly of the biceps is divided into a long and a short head. In its entirety, it extends from the shoulder to the elbow. Emerging from the under the pectoralis major, the belly expands into its familiar bulging shape and ends abruptly into a very strong, narrow tendon. This tendon inserts deep in the elbow between the extensor and flexor masses of the forearm.

The front profile of the biceps (seen in side view) is straight for a considerable length when the elbow is extended, but becomes quite rounded and bulging when the elbow is fully flexed. The deep posterior surface of the belly of the biceps is flattened where it lies on the brachialis. The separation between the heads, which at times may extend all the way down the belly, is usually not very pronounced. The different characteristics of the two bellies can be seen at the upper end of the belly when the elbow is fully flexed—the long head is fuller, more rounded, and directed toward the head of the humerus, whereas the short head is more elongate and directed toward the armpit.

At the inferior end of the muscle, the fibers at the medial side of the belly descend lower than those of the lateral side. The medial portion of the belly may further divide longitudinally, forming a narrow, elongated muscle slip on its extreme medial edge. This is not the separation between the medial and lateral heads.

The **bicipital aponeurosis** (lacertus fibrosus) is a broad, sheetlike, aponeurotic expansion which originates off the anterior surface of the muscle fibers on the medial side of the lower end of the biceps and off the front surface of the upper portion of its tendon (it lies medial to the tendon of insertion of the biceps). It fans out downward and medially, wrapping around and constricting the bulging form of the forearm flexor mass a couple of inches below their origin at the medial epicondyle of the humerus. The constricting action of the aponeurosis creates either a wide or narrow furrow, or a flattening, on the forearm flexor mass, so that the flexor mass bulges above and below the apo-



neurosis. This aponeurotic constriction is minimal when the forearm is pronated.

When the elbow is flexed to 90°, the forearm supinated, and the muscles tensed, the bicipital aponeurosis can directly be seen as its medial edge creates a ridge between the biceps and forearm.

When the forearm is pronated, the muscle belly of the biceps is stretched and becomes longer and thinner, because the point of insertion is moved farther away from the points of origin as the radius rotates. When supinated, the belly shortens and thickens, and its lower end can be seen rising. More of the tendon of insertion becomes superficial when the forearm is supinated.

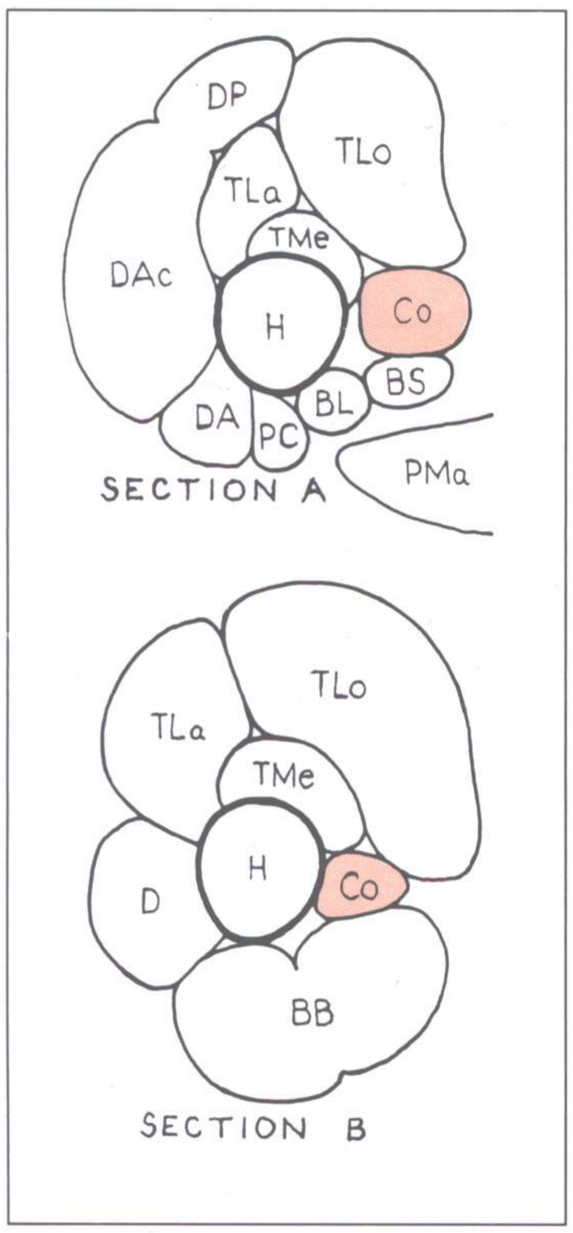
The **long head** of the biceps is located on the lateral side. It begins as a round tendon at the top of the socket of the scapula, arches over the top of the humerus, and descends in the bony intertubercular sulcus (bicipital groove). Emerging from its bony groove, it expands into its fleshy head.

The **short head** begins from the more medial origin of the coracoid process of the scapula. It shifts the upper end of the long axis of the biceps medially, away from the long axis of the humerus and toward the armpit. This shifting, combined with the form of the coracobrachialis, adds muscular fullness on the inside of the upper arm. The short head begins as a strong, flat, narrow tendon, composed mostly of tendinous fibers, but it also has some fleshy fibers. The upper end of the short head is closely applied to, but distinct from, the fleshy belly of the coracobrachialis muscle underneath it.

The muscle fibers of both heads continue superiorly under the pectoralis major and deltoid, but taper off into their tendons soon after they pass under them. The fleshy fibers of the long head stop where its tendon first enters the bicipital groove, while the majority of the fleshy fibers of the short head stop at a level higher than this, approximately three inches below the tip of the coracoid process. The overall belly (both heads) is wider side to side than it is deep front to back when the elbow is extended, but has the same width and thickness when the elbow is flexed.

On the inside of the arm, the biceps is in contact with the triceps at its middle third only (separated slightly by the neurovascular bundle).

When the elbow is straight and the arm is medially rotated, a subtle oblique constriction appears transversely across the biceps at its midpoint (at the level of the insertion of the deltoid). This subtle wide furrow passes downward and medially, best seen in side view of the arm. It is caused by the inferior portion of the deltoid pulling on the fascia that lies on the surface of the biceps, which in turn compresses the muscle underneath.



Coracobrachialis

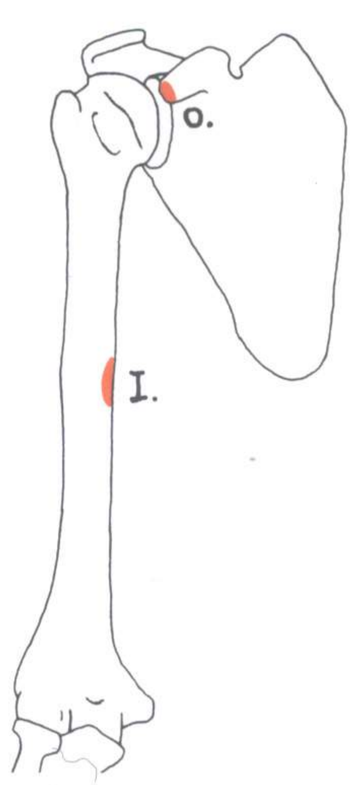
ORIGIN Tip of the coracoid process of the scapula (in common with the short head of the biceps).

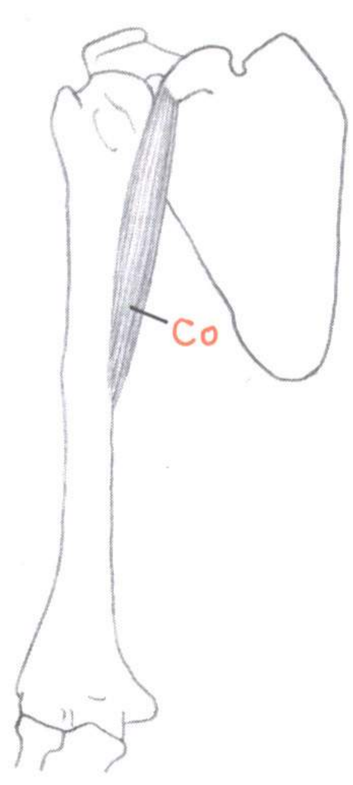
INSERTION Short vertical line halfway down the humerus on its medial surface.

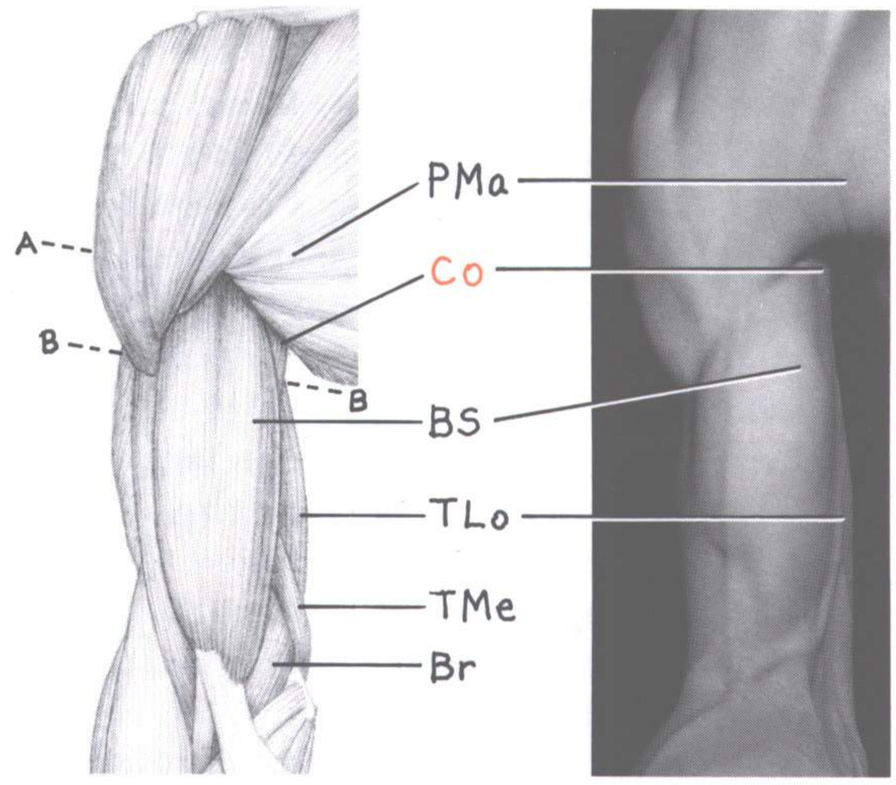
ACTION Flexes and adducts the arm at the shoulder joint.

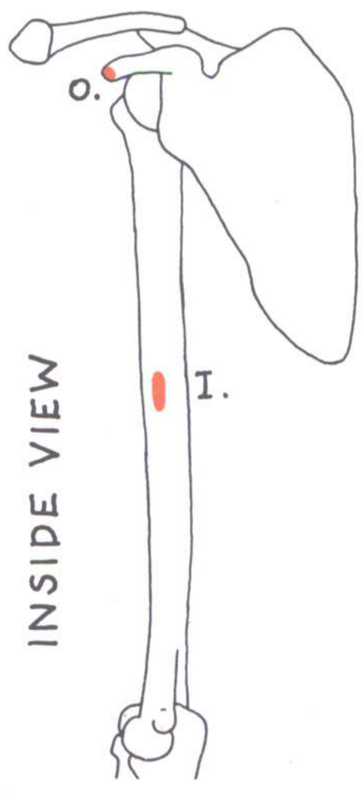
STRUCTURE The coracobrachialis is a thick cylindrical muscle that is partially seen on the inside of the upper end of the raised arm, near the armpit. It runs alongside, but separate from, the short head of the biceps. The belly of the coracobrachialis is seen on the surface for only a short distance before it dives deeply between the biceps and the medial head of the triceps. The short head of the biceps covers most of the anterior surface of the coracobrachialis.

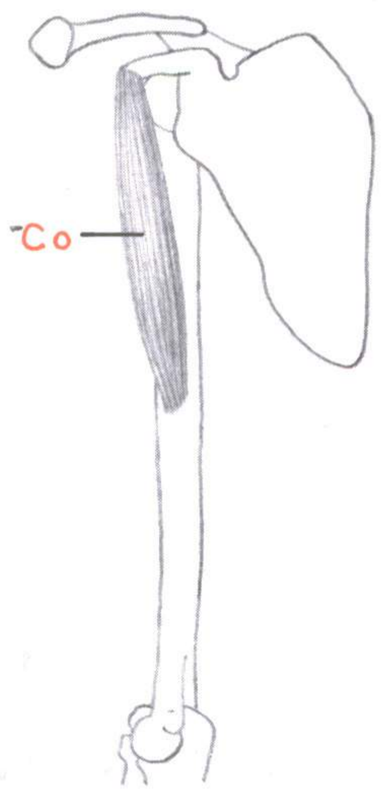
The coracobrachialis and biceps are separated from the triceps by a groove within which lie the nerves and blood vessels (surrounded by fat) of the arm.

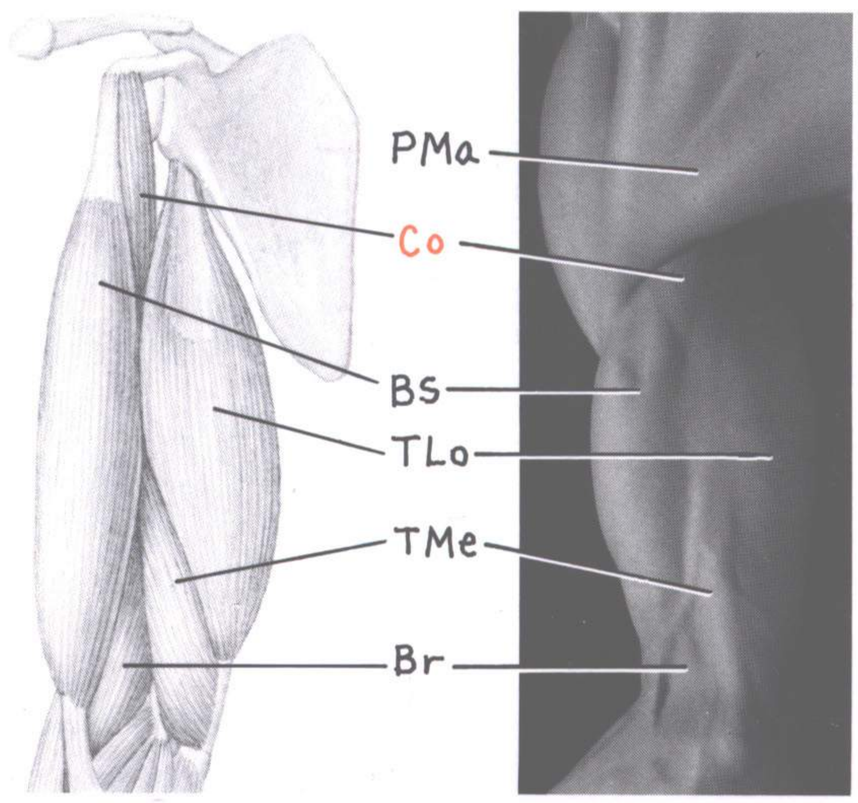




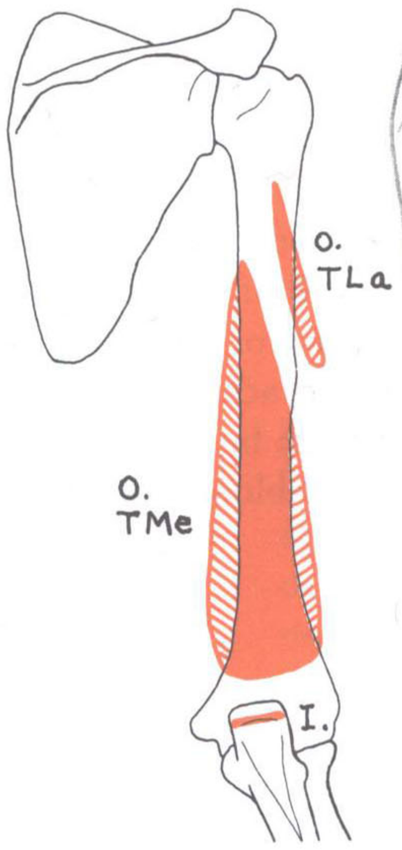


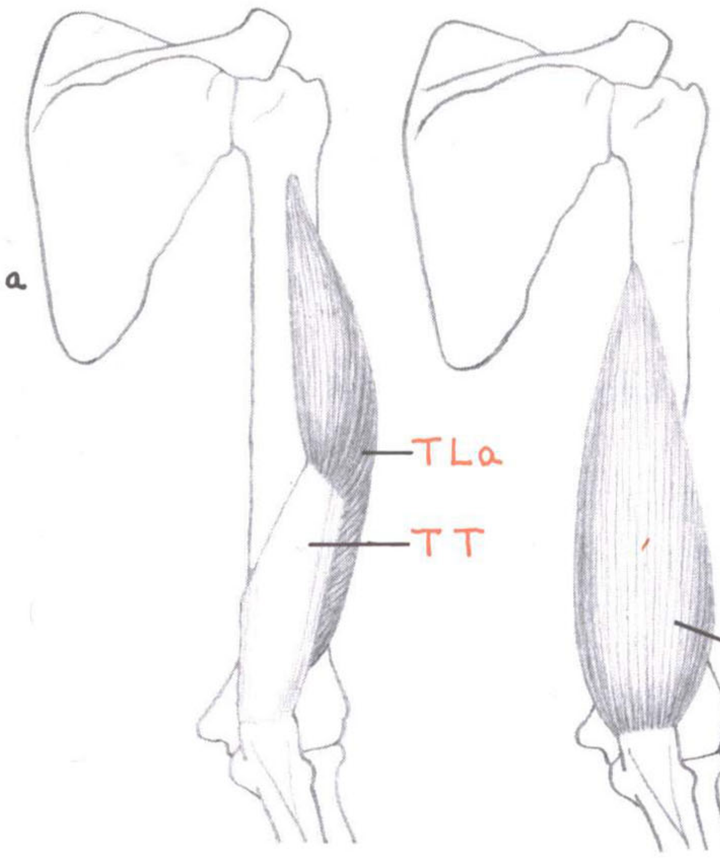


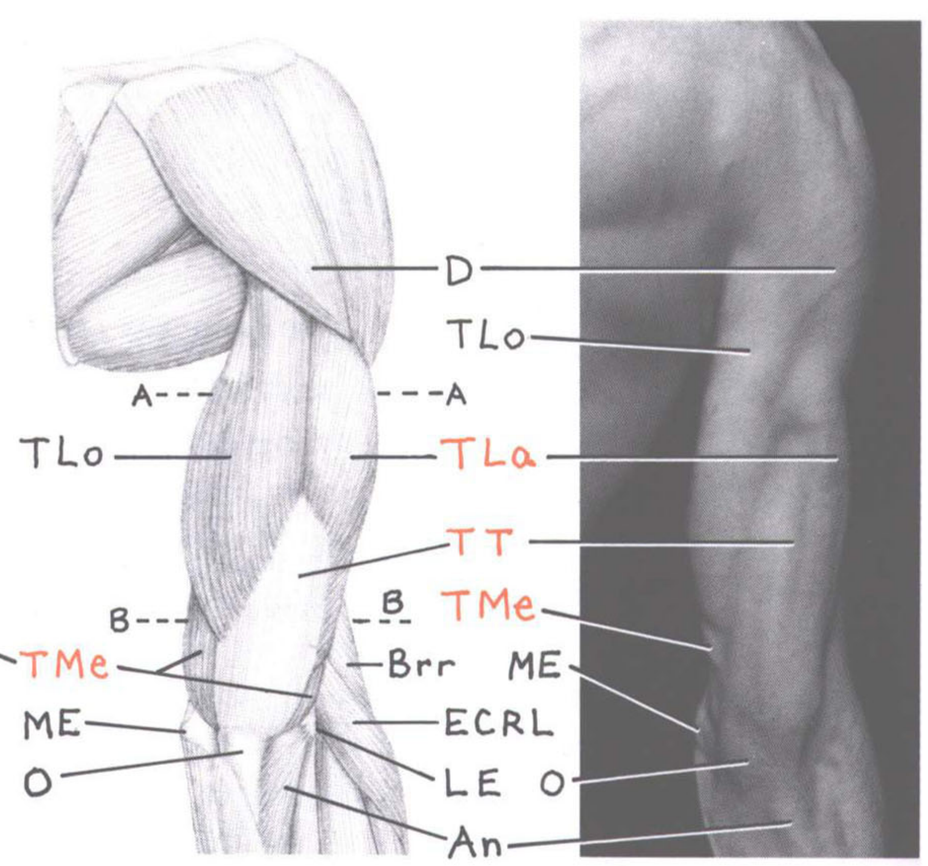


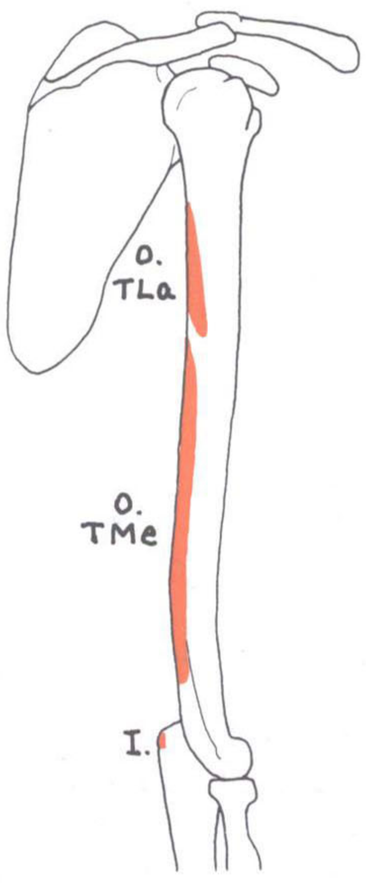


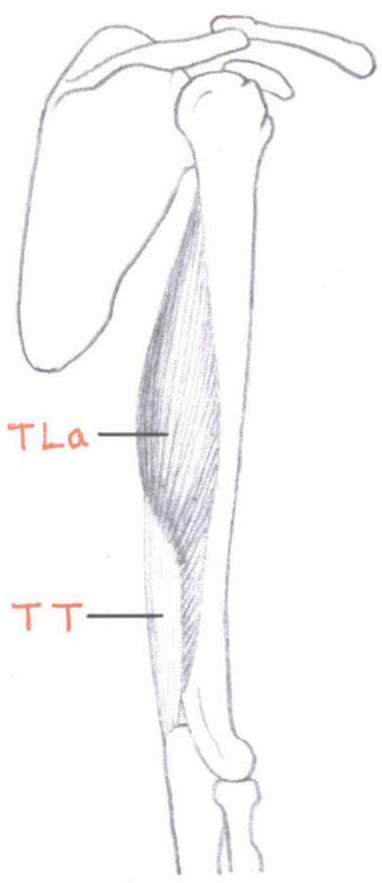
BB *Biceps brachii* **Br** *Brachialis* **BS** *Biceps brachii—short head* **Co** *Coracobrachialis* **H** *Humerus*
PMa *Pectoralis major* **TLo** *Triceps—long head* **TMe** *Triceps—medial head*

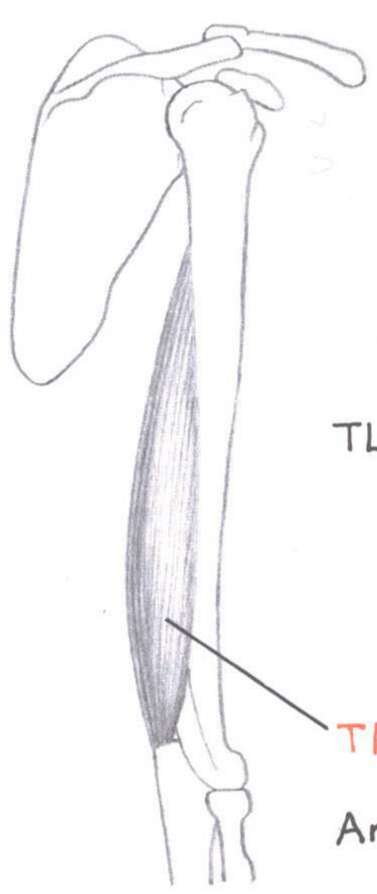


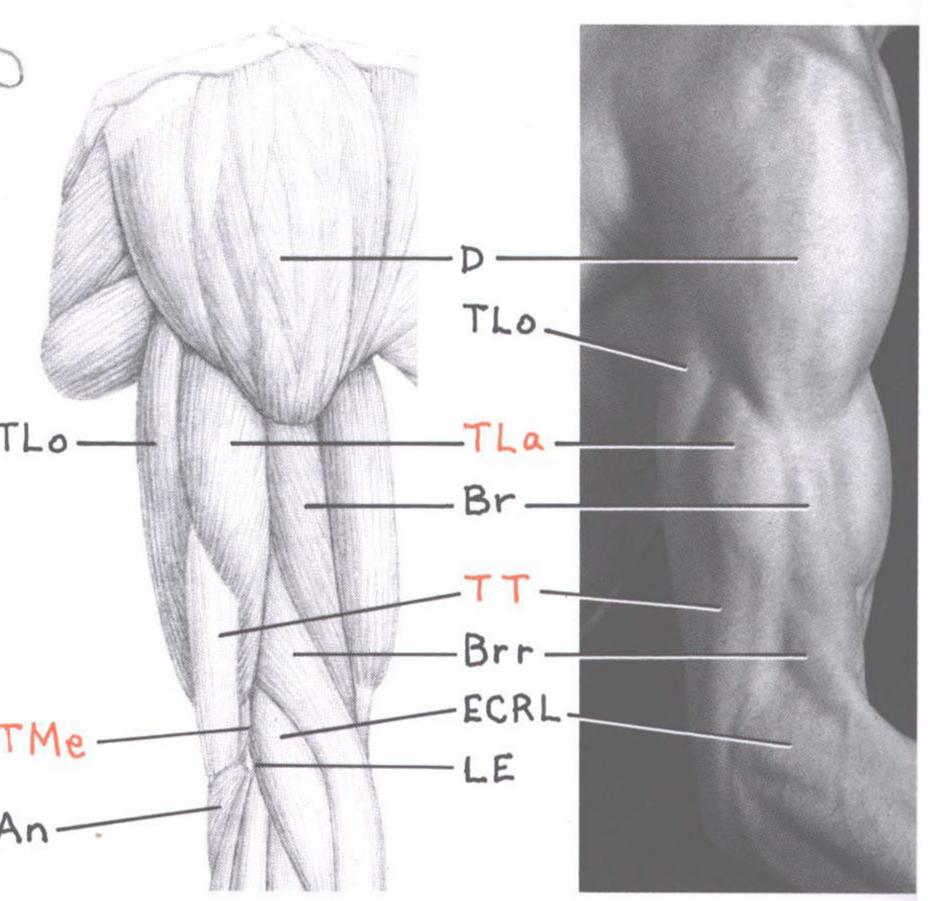


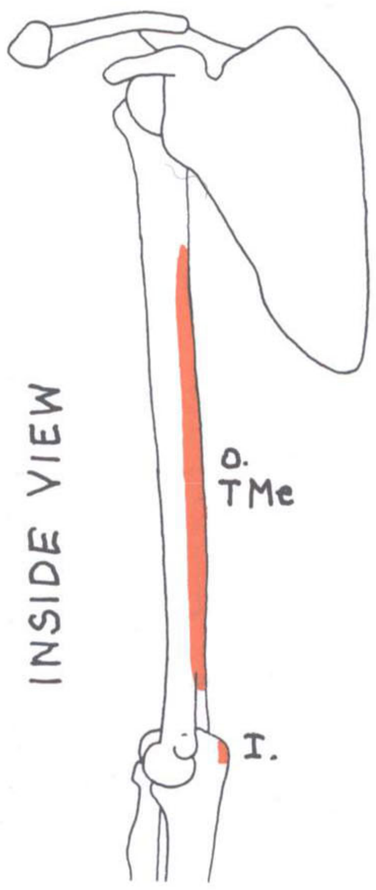


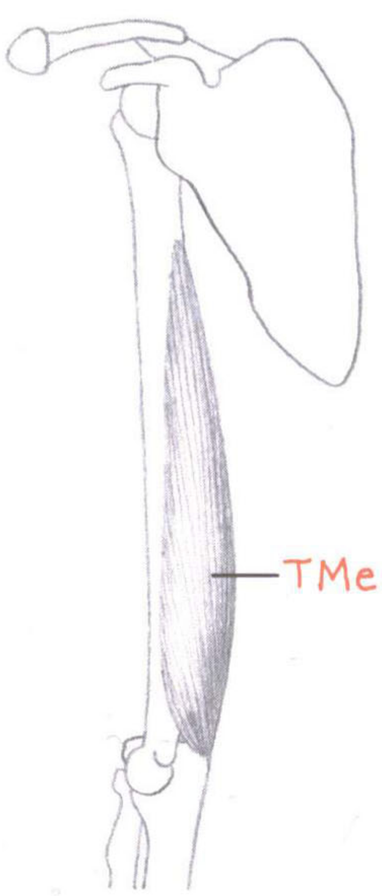


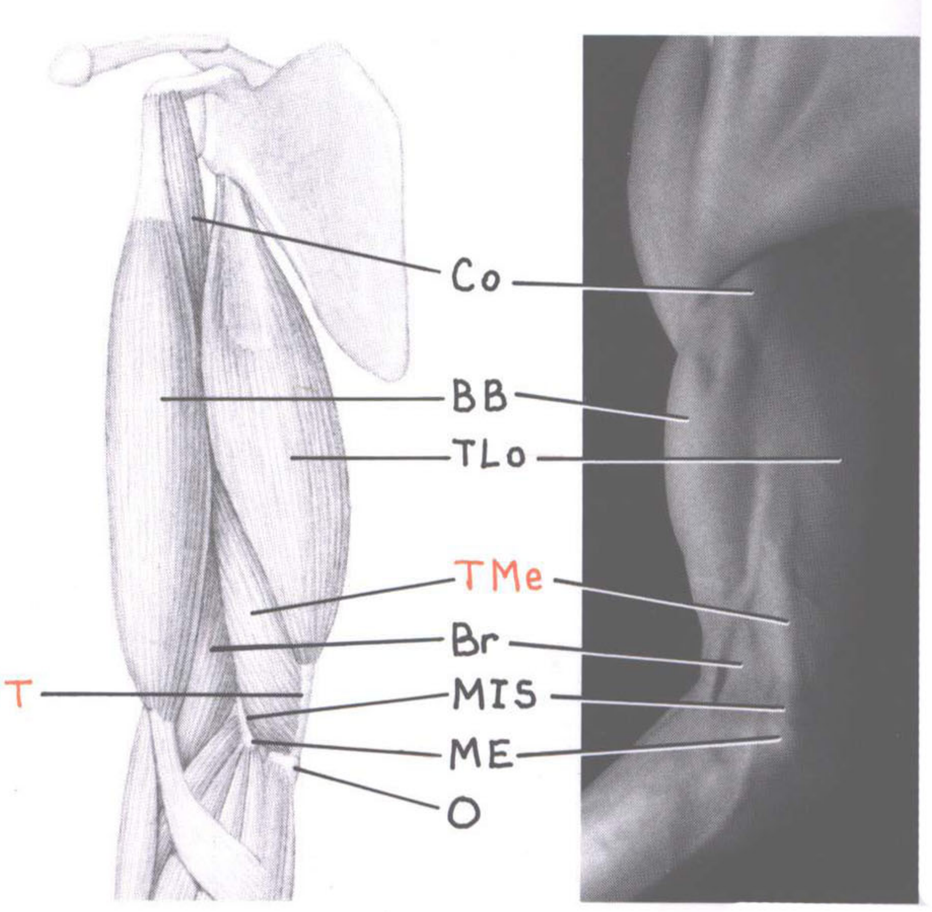




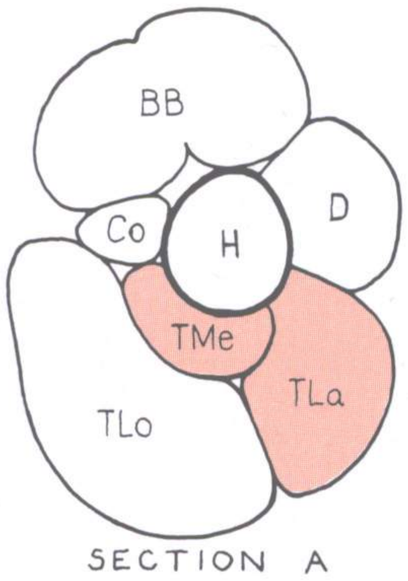




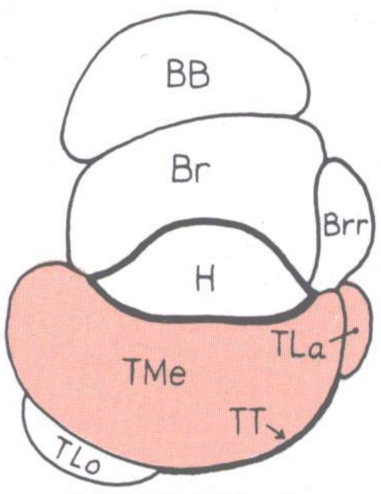




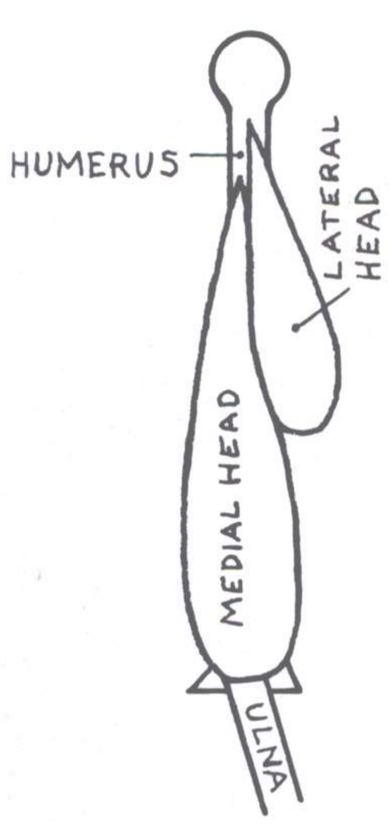
An *Anconeus* **BB** *Biceps brachii* **Br** *Brachialis* **Brr** *Brachioradialis* **Co** *Coracobrachialis*
D *Deltoid* **ECRL** *Extensor carpi radialis longus* **H** *Humerus* **LE** *Lateral epicondyle*
ME *Medial epicondyle* **MIS** *Medial intermuscular septum* **O** *Olecranon* **TLa** *Triceps—lateral head*
TLo *Triceps—long head* **TMe** *Triceps—medial head* **TT** *Triceps tendon*



SECTION A



SECTION B



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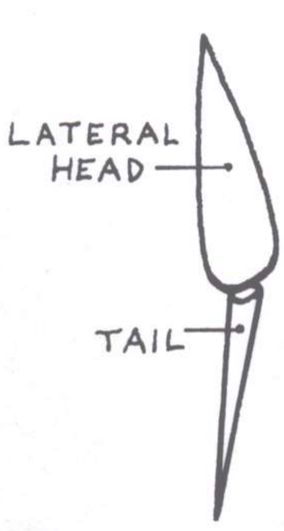


BACK VIEW

Triceps Brachii—Lateral and Medial Heads

ORIGIN *Lateral head:* A vertical line on the outer back corner of the shaft of the humerus, beginning just below the head of the humerus and ending almost halfway down the bone, and the adjacent lateral intermuscular septum. *Medial head:* A large, elongated, triangular area occupying the lower portion of the back surface of the humerus, which extends upward on the medial side of the back surface of the shaft, and from the posterior surfaces of part of the lateral intermuscular septum and all of the medial intermuscular septum.

INSERTION *Lateral head:* Upper two-thirds of the lateral edge and deep aspect of the upper portion of the triceps tendon. *Medial head:* Lower third of both the medial and lateral edges and the lower portion of the deep aspect of the triceps tendon. The triceps tendon inserts into the horizontal posterior edge of the top of the olecranon process of the ulna.

ACTION Powerfully extend the forearm at the elbow joint.

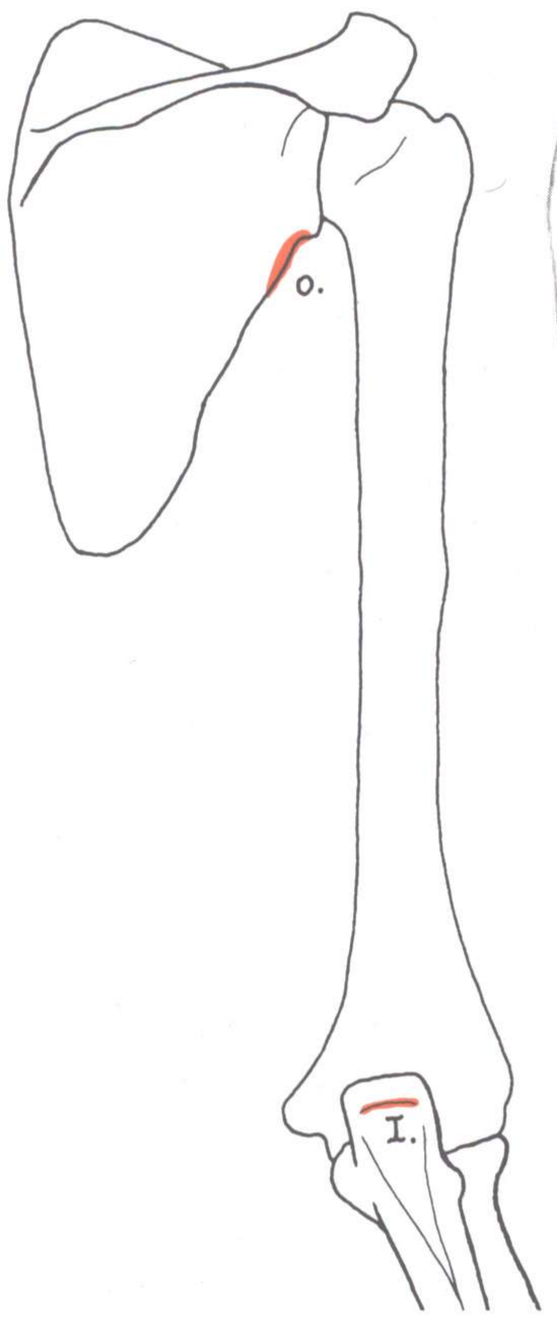
STRUCTURE The majority of the superficial portion of the **lateral head** appears as an elliptical or teardrop-shaped form located on the middle third of the outer back corner of the upper arm (more on the side than on the back). The remaining fibers of the lateral head continue down the lateral edge of the triceps tendon, from the bottom of the teardrop, as a descending "**tail.**" These fibers insert into the edge of the tendon in an irregular fashion. When the triceps extends the elbow joint, the elongated muscular ridge of the tail appears as a narrow inverted cone. The lateral head can easily be seen from the front view.

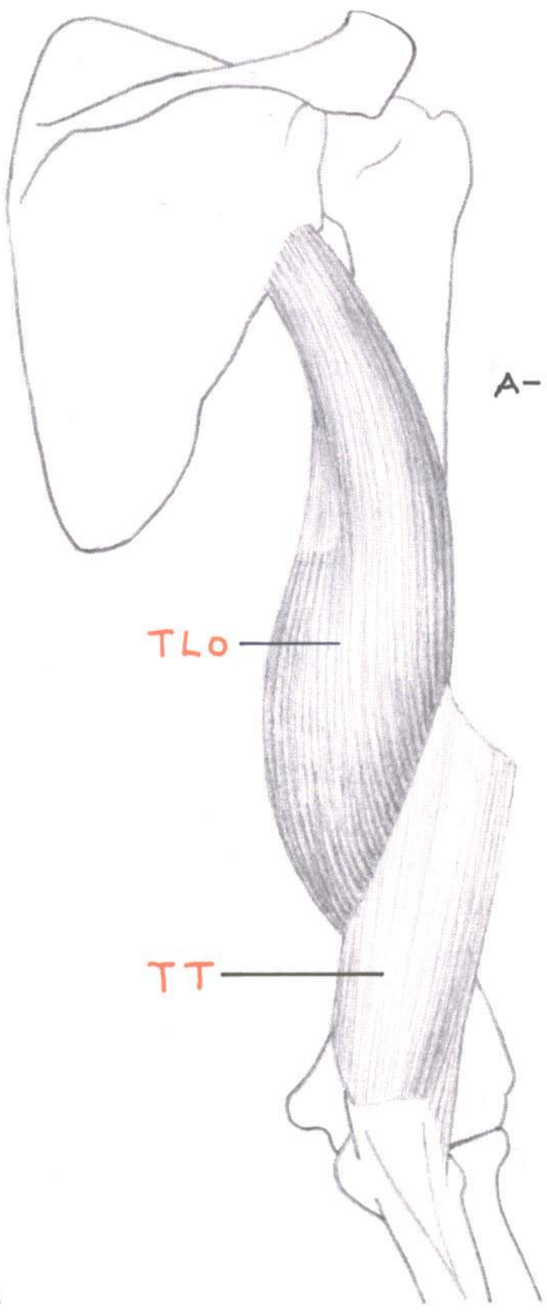
The **medial head** by itself is a flattened teardrop shape, pointed superiorly, that curves around the back of the lower half of the humerus (side to side, see cross section). Because it is mostly covered by the long head and the triceps tendon, it is seen on the surface as a long, narrow, cylindrical form on the *lower half* of the inner back corner of the upper arm. It can sometimes be seen from the front view. Superiorly, this form dives deeply between the long head of the triceps and the biceps to reach the upper extent of its attachment on the humerus; it never appears on the surface on the *upper half* of the inside of the upper arm.

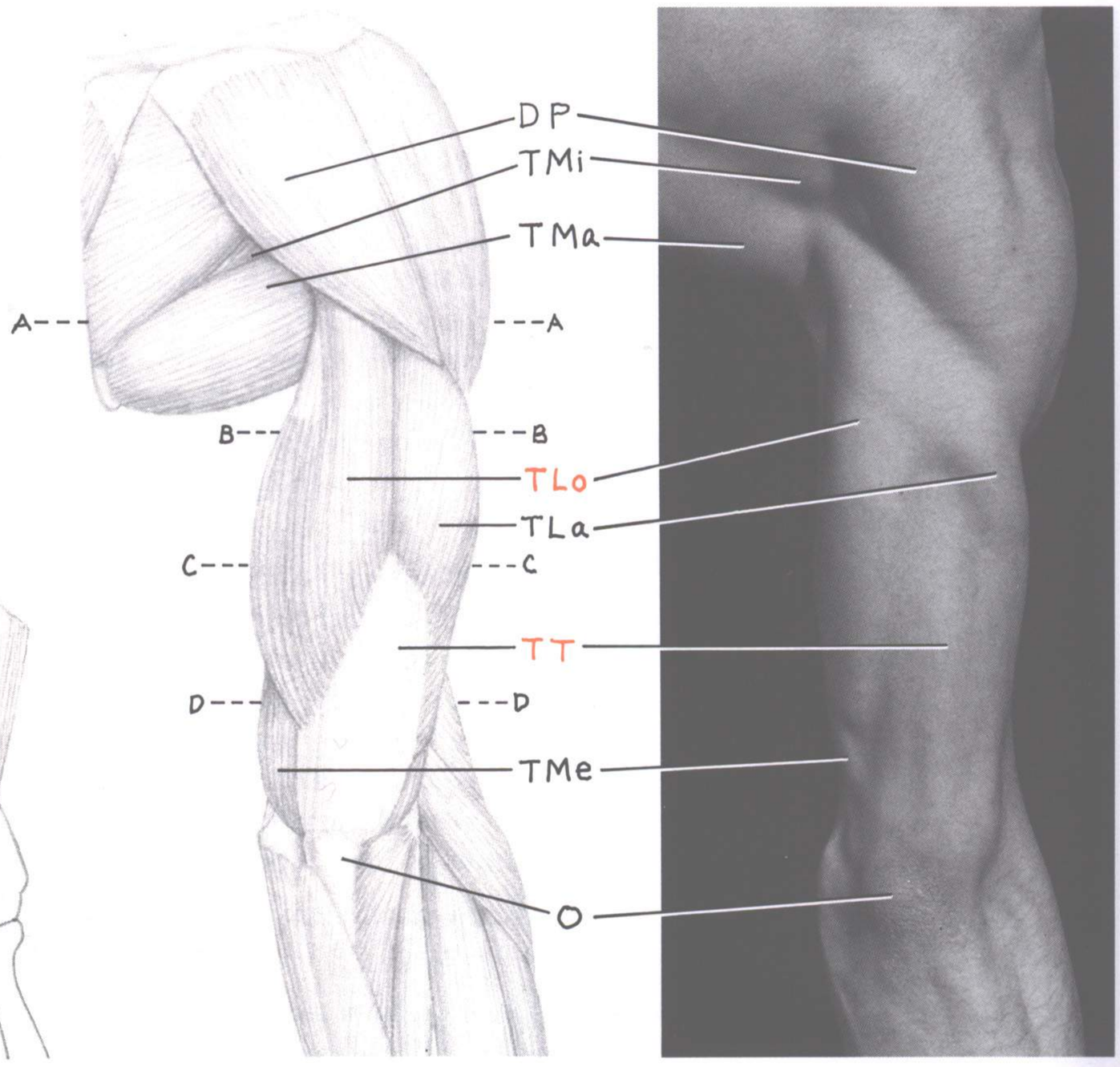
A large part of the medial head lies under the triceps tendon. Although a narrow portion comes to the surface past the lateral edge of the tendon, the medial head is usually not distinct there, but may add to the form of the lower end of the tail of the lateral head. Most of the fibers of the medial head attach to the deep aspect of the tendon, but some of them actually insert into the olecranon directly.

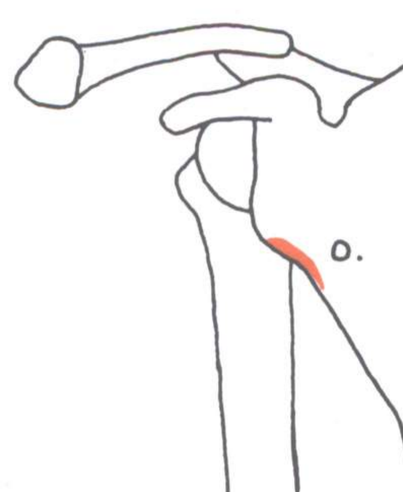
On either side of the humerus, the medial head takes origin from the posterior surfaces of the **intermuscular septa.** The subcutaneous edges of the medial and lateral intermuscular septa can occasionally be seen on the surface—medially as a short, thin, cordlike elevation ascending from the medial epicondyle of the humerus (easily felt when the elbow is fully extended) and laterally as a short ridge rising from the lateral epicondyle of the humerus (when the elbow joint is flexed 90° and extended against resistance). The edge of the lateral intermuscular septum lies *anterior* to the lateral edge of the triceps tendon (just above the elbow), and the two may or may not be separated by the muscular fibers of the tail of the lateral head. Inferiorly, the intermuscular septum attaches to the lateral epicondyle, whereas the triceps tendon attaches to the olecranon or onto the surface of the anconeus.

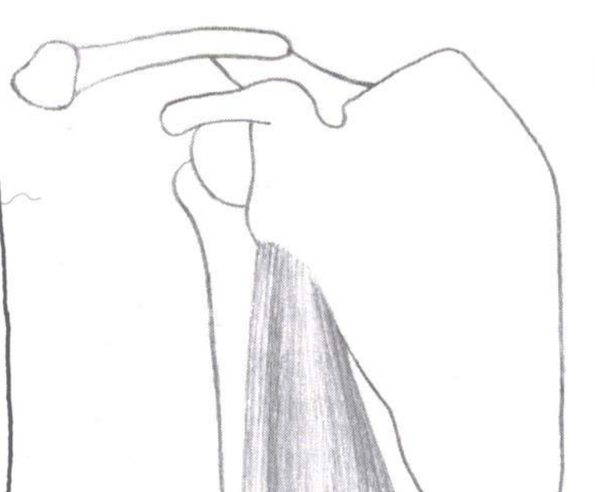
Because the lateral and medial heads originate in part from the lateral and medial intermuscular septa, the width of the belly of the triceps is greater than the width of its origin from the humerus.

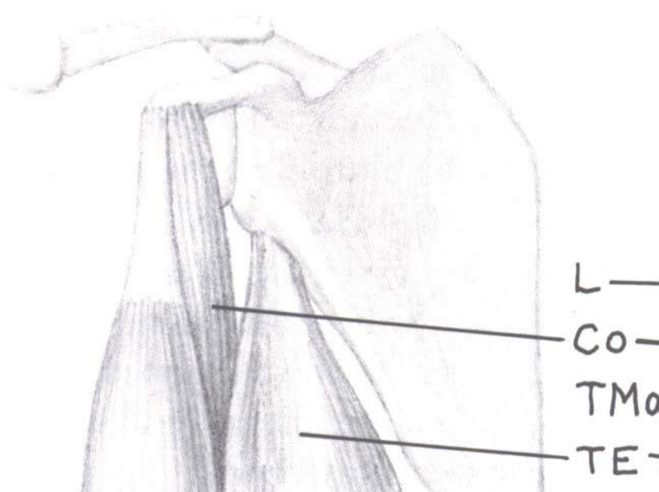




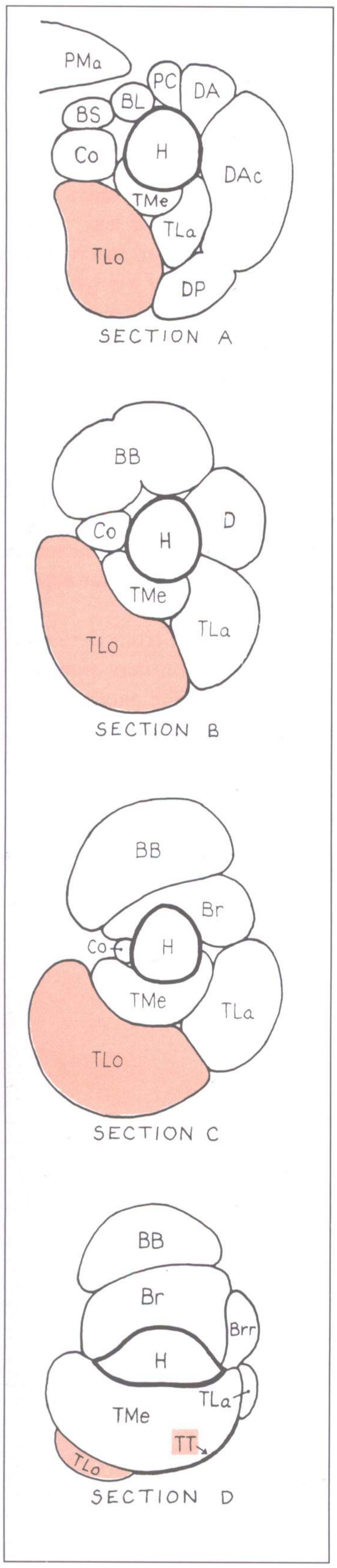








BB *Biceps brachii* **Br** *Brachialis* **Co** *Coracobrachialis* **D** *Deltoid* **DP** *Deltoid—posterior portion* **H** *Humerus* **L** *Latissimus dorsi* **O** *Olecranon* **TE** *Tendinous expansion* **TLa** *Triceps—lateral head* **TLo** *Triceps—long head* **TMa** *Teres major* **TMe** *Triceps—medial head* **TMi** *Teres minor* **TT** *Triceps tendon*



Triceps Brachii—Long Head

ORIGIN Infraglenoid tubercle at the bottom of the socket of the scapula and a short distance below it along the lateral (axillary) border of the scapula. It does not originate from the humerus.

INSERTION Upper two-thirds of the medial edge of the tendon of insertion of the triceps, which in turn inserts into the horizontal posterior edge of the top of the olecranon process of the ulna.

ACTION Extends the forearm at the elbow joint; extends the arm from a previously flexed position at the shoulder joint.

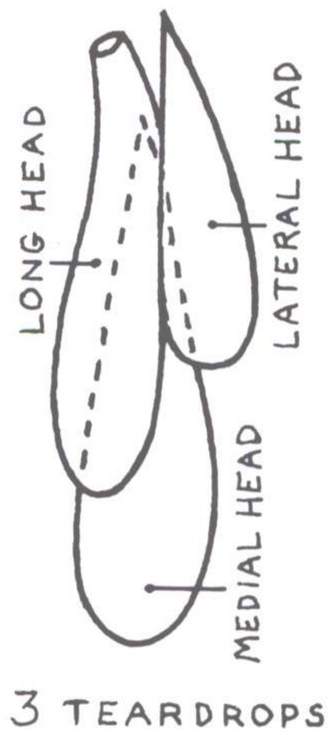
STRUCTURE Largest of the three heads of the triceps, this flattened, teardrop-shaped head is located on the inner back corner of the upper arm. It descends three-fourths of the way down the arm. The inferior end of the head is pointed.

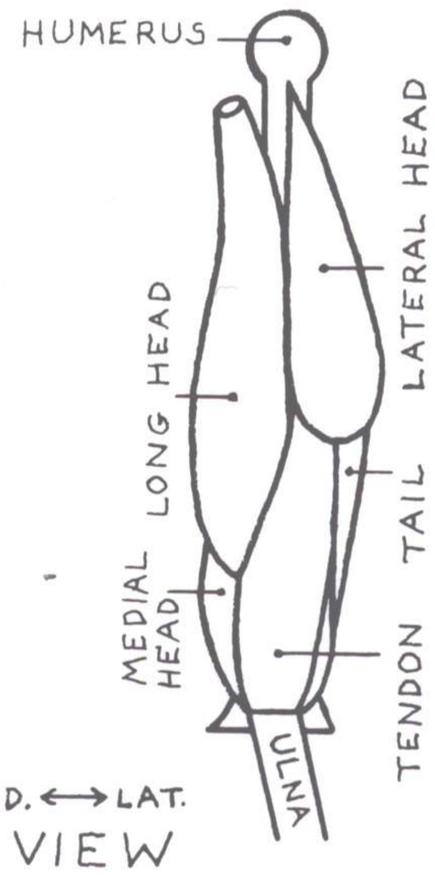
At the upper portion of the *inside* of the arm, the volume of the long head projects quite far forward, reaching almost three-fourths of the way toward the front of the arm. The upper end of the long head (maintaining a wide, fleshy thickness) dives *between the teres major and teres minor muscles* toward its attachment on the scapula. With the arm down by the side, the upper portion of the long head, just before it disappears between the teres muscles, is crossed by an almost vertical skin fold (running perpendicular to the long head muscle fibers).

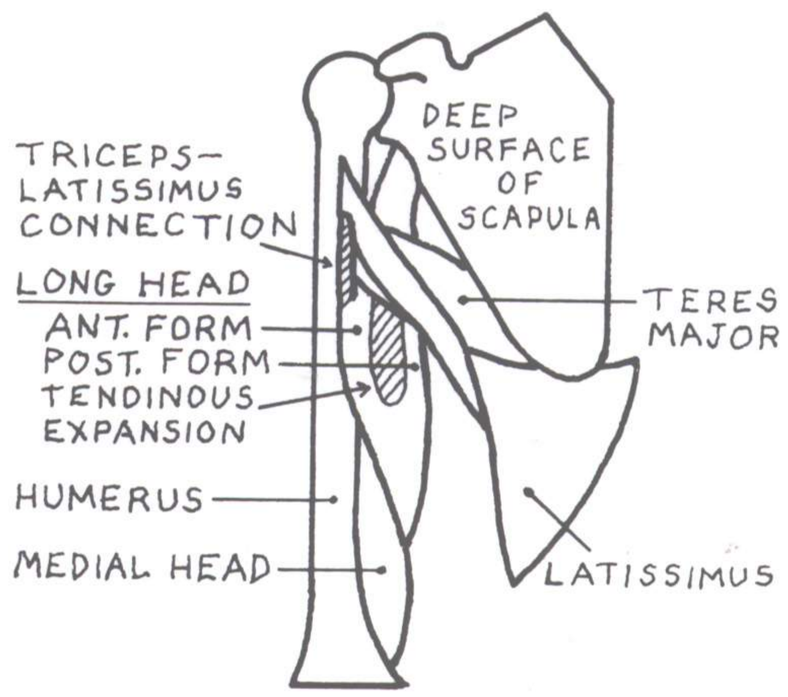
As the long head emerges from between the teres muscles, it is flattened from above to below. It then twists medially, flattens considerably side to side, and expands front to back. Thin, tendinous material coming off the origin of the long head at the scapula descends and expands onto the surface of the upper part of this flattened head (on the medial aspect of the arm). This nonelastic material compresses the fleshy head when it is tensed, creating a wide vertical furrow that separates the upper end of the long head into anterior and posterior forms. The elongated anterior form, *part of the long head,* is commonly mistaken for the medial head of the triceps.

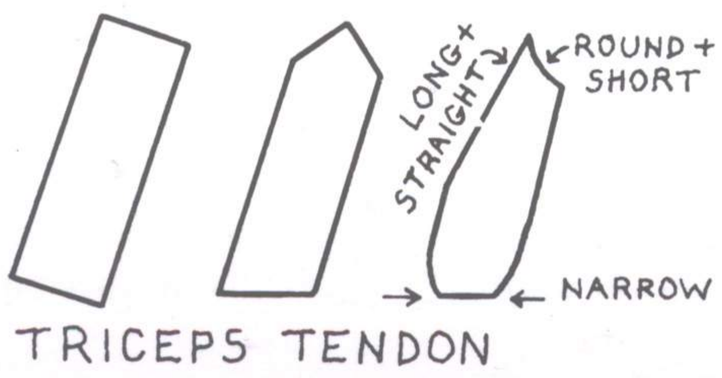
In the inside view of the upper arm, the entire triceps muscle is seen to have a double curve along its front edge—the long head curves anteriorly on the upper half of the arm, the medial head curves anteriorly on the lower half.

In the armpit, there is usually a tendinous and/or muscular connection, the **triceps-latissimus connection,** between the *anterior edge* of the long head of the triceps and the tendon of the latissimus dorsi near its insertion. This connection represents the dorsoepitrochlearis bra-









chii muscle of the ape and directs the *anterior edge* of the long head of the triceps to the tendon of the latissimus dorsi *in front of,* rather than behind, the teres major. The front edge of the long head appears to dive between the teres major/latissimus tendons and the coracobrachialis. This connection is noticeable in the armpit when the arm is raised and the muscles tensed. Nevertheless, the bulk of the head still passes behind the teres major (between the two teres muscles).

The long head, a two-joint muscle, crosses the shoulder and elbow joints, whereas the lateral and medial heads of the triceps only cross the elbow joint. In the side view of the arm, the long head has a more posterior projection than does the lateral head, especially superiorly. The long head can be seen in the front view of the arm.

The **tendon of the triceps,** receiving the fibers of all three heads of the triceps, inserts into the olecranon process of the ulna. The superior tip of the tendon reaches the middle of the arm (midway between the acromion and olecranon) in the straight arm position. Its lower end narrows slightly before inserting. The plane of the tendon is curved side to side (as it lies on the bulk of the medial head, not the humerus), and the superior end of its axis shifts laterally. The triceps tendon often appears as a slightly depressed curved plane because of the bulk of the surrounding muscle fibers inserting into its edges, especially the upper end where the lateral and long heads insert. The line of insertion of the fibers of the long head into the tendon is a downwardly curved line and is especially pronounced; the line of insertion of the fibers of the long head is longer and more or less straight. The tail of the lateral head inserts continuously down the lateral edge of the tendon.

The side edges of the tendon may register as vertical grooves as they cut into the bulk of the underlying medial head, especially the medial edge, which isolates the superficial medial portion of the medial head into an elongated form on the lower half of the inner back corner of the upper arm. In addition, one or more vertical ridges or grooves may appear on the surface of the tendon as it compresses the belly beneath. A central furrow may become quite pronounced (often seen in the flexed elbow).

Aponeurotic fibers originating from the lateral portion of the triceps tendon may extend downward onto the surface of the anconeus muscle, passing a short distance lateral to the olecranon. The lateral edge of the tendon may therefore appear to continue downward onto the upper part of the back of the forearm, rather than into its insertion on the olecranon.

The Forearm Muscles

The *FOREARM,* lower arm, or antebrachium, contains fifteen muscles that produce surface form. In order to simplify this complex region, most of these muscles can be divided into three basic forearm muscle groups—flexor, extensor, and ridge—based on their function and location. Certain liberties have been taken for the sake of simplicity. See the individual muscle descriptions for complete attachments and function.

The forearm muscles are first separated into two groups—the **flexor** and **extensor muscles.** The *three flexor muscles* (flexor carpi radialis, flexor carpi ulnaris, and flexor digitorum superficialis) originate from the *medical epicondyle* of the humerus and pass to the *palmar (anterior) aspect of the hand.* The *three extensor muscles* (extensor carpi radialis brevis, extensor carpi ulnaris, and extensor digitorum) originate from the *lateral epicondyle* of the humerus and pass to the *dorsal (posterior) aspect of the hand.*

All these flexor and extensor muscles are located on the forearm, cross the wrist joint, and insert into and move the hand and fingers. The **wrist muscles** (flexor/extensor *carpi* radialis/ulnaris) cross the wrist joint and soon insert into the hand skeleton. The **finger flexor** and **finger extensor** pass down the middle of the front and back of the forearm, respectively, between the wrist muscles. They cross the wrist joint and proceed downward toward the ends of the fingers.

When the forearm is supinated, the flexor muscles pass obliquely down the forearm from the medial epicondyle to the palmar aspect of the hand, while the extensor muscles pass straight down the back of the forearm (in line with the axis of the forearm) from the lateral epicondyle to the back of the hand. In pronation the situation is reversed: the flexors are straight and the extensors oblique.

A cross section of the wrist made through the distal ends of the radius and ulna is basically rectangular in shape (because of the boxlike nature of the wrist itself); in the anatomical position, the radius is located laterally, the ulna medially. Highly simplified, the rectangle of the cross section has a **wrist cable** in each corner (the cables are the tendons of each of the wrist muscles). Working in various pairs, the two wrist flexors (flexors carpi radialis and ulnaris) flex the wrist; the two wrist extensors (extensors carpi radialis and ulnaris) extend the wrist; the flexor and extensor on the radial side of the wrist (flexor carpi radialis and extensor carpi radialis) deviate the hand toward the radius; and the flexor and extensor on the ulnar side of the wrist (flexor carpi ulnaris and extensor carpi ulnaris) deviate the hand toward the ulna. Working in sequence, they circumduct the hand at the wrist. Working simultaneously, they pull the hand into the wrist socket, fixing and stabilizing that joint (which allows the fingers to move independently of the wrist joint).

The cables of the finger flexor and extensor are located on the palmar and dorsal sides of the wrist cross section, respectively, midway between the wrist cables. Not only do they flex or extend their respective fingers, but they also assist in flexing or extending the wrist joint.

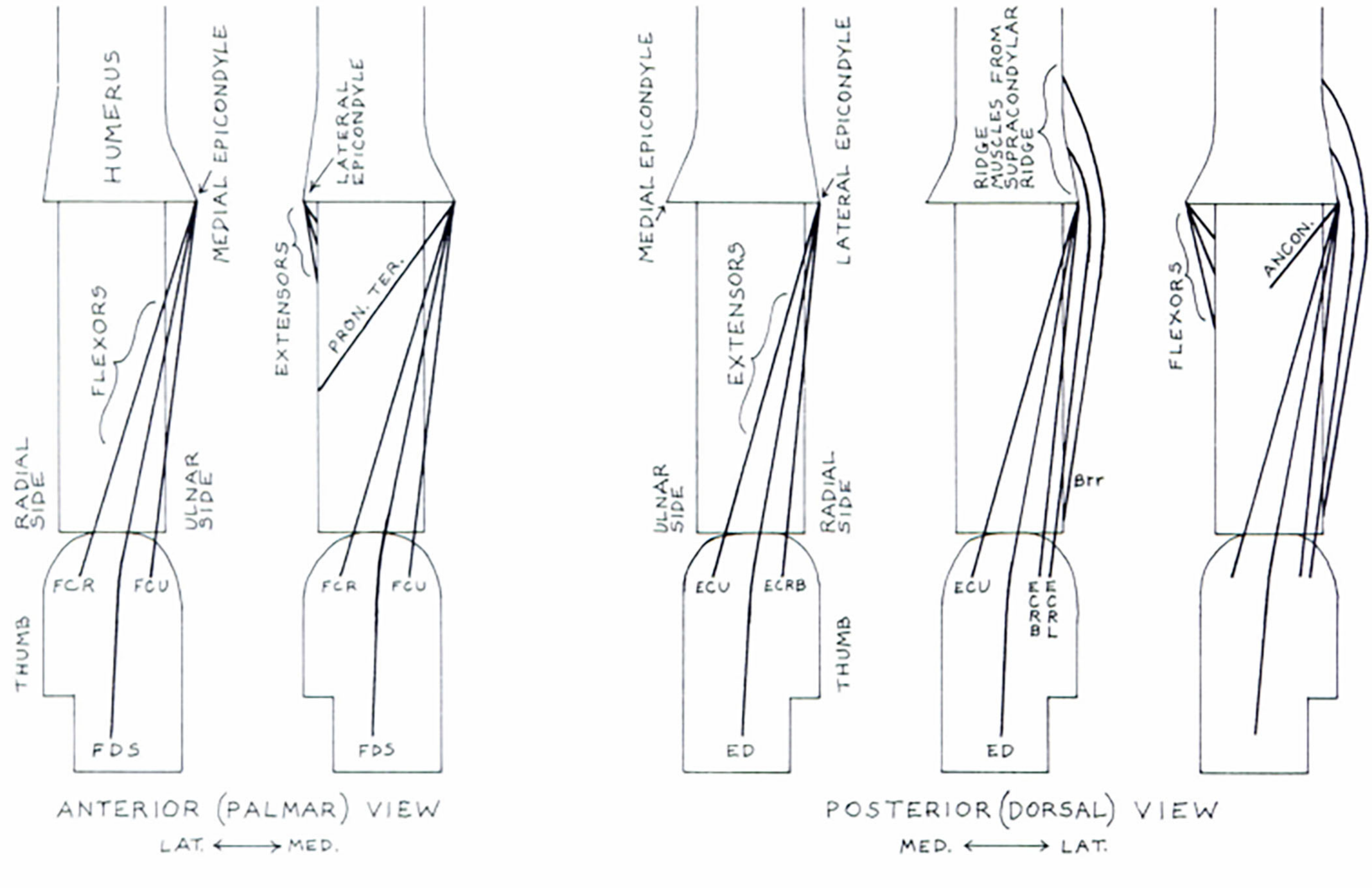
The outside of the forearm has a second muscle group, running adjacent to the extensor muscles, which in this book are called the **ridge muscles.** The *two ridge muscles* originate from the *supracondylar ridge* of the humerus, immediately above the lateral epicondyle, and pass downward to the *radial side of the wrist.* The muscles of the ridge group are the extensor carpi radialis longus, which crosses the wrist, and the brachioradialis, which does not; the brachioradialis inserts into the distal end of the radius.

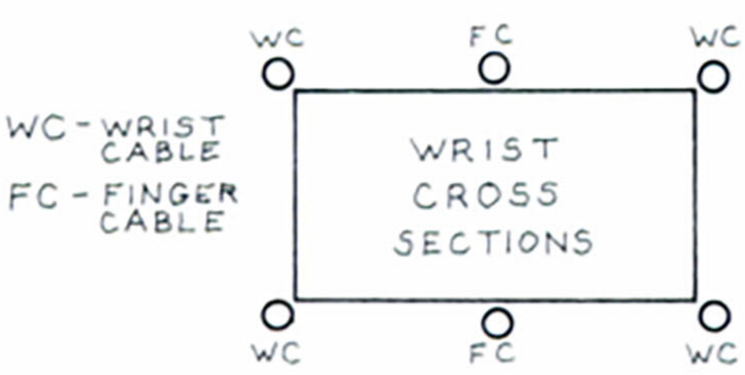
The following three additions (modifications) are now made to the basic plan—flexor additions, extensor additions, and short epicondyle additions.

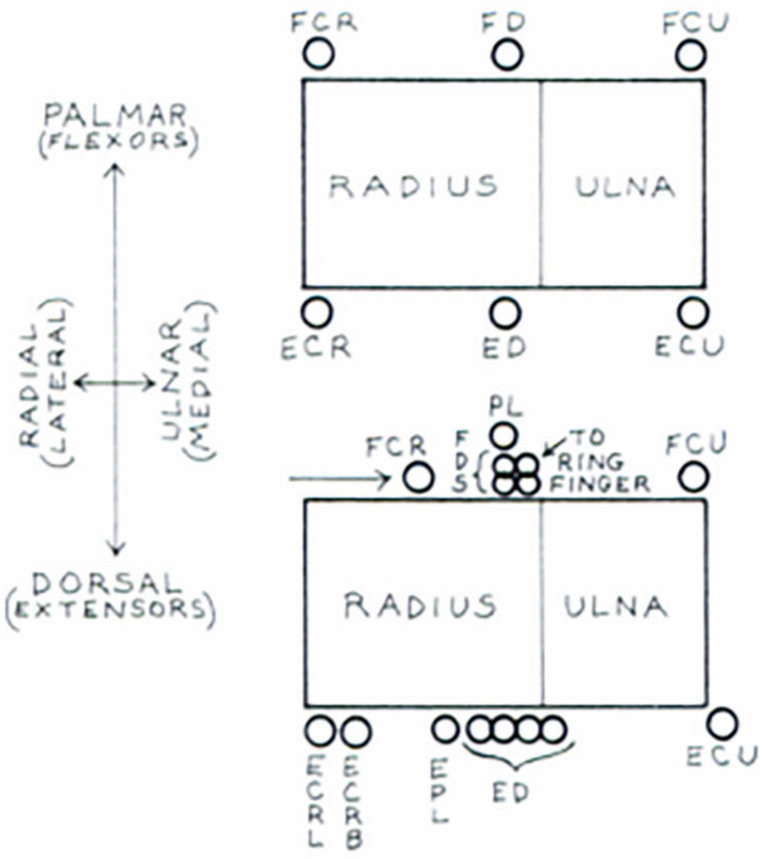
- **Flexor additions:** Dividing the single cable of the flexor digitorum superficialis at the wrist into four tendons (the tendon to the ring finger is superficial and usually visible); placement of the prominent tendon of the palmaris longus directly on top of the flexor digitorum superficialis tendons at the wrist (its belly also lies on top of the belly of the flexor digitorum superficialis, but they are not distinct); shifting the flexor carpi radialis tendon medially toward the tendon of the palmaris longus.
- **Extensor additions:** Dividing the single cable of the extensor digitorum tendon at the wrist into four tendons; adding the tendon of the extensor pollicis to the back of the wrist next to the extensor digitorum tendons (the five fingers of the hand have *five visible finger extensors,* one tendon per finger); dividing the extensor carpi radialis cable at the wrist into its two tendons—a longus and a brevis.
- **Short epicondyle additions:** Two additions are added to the upper half of the forearm. Each epicondyle of the humerus has a short muscle that does not reach the wrist, but inserts into a forearm bone at or above its halfway point. The pronator teres, one of the medial epicondyle muscles, inserts into the radius. The anconeus, one of the lateral epicondyle muscles (actually an elbow joint extensor), inserts into the ulna.

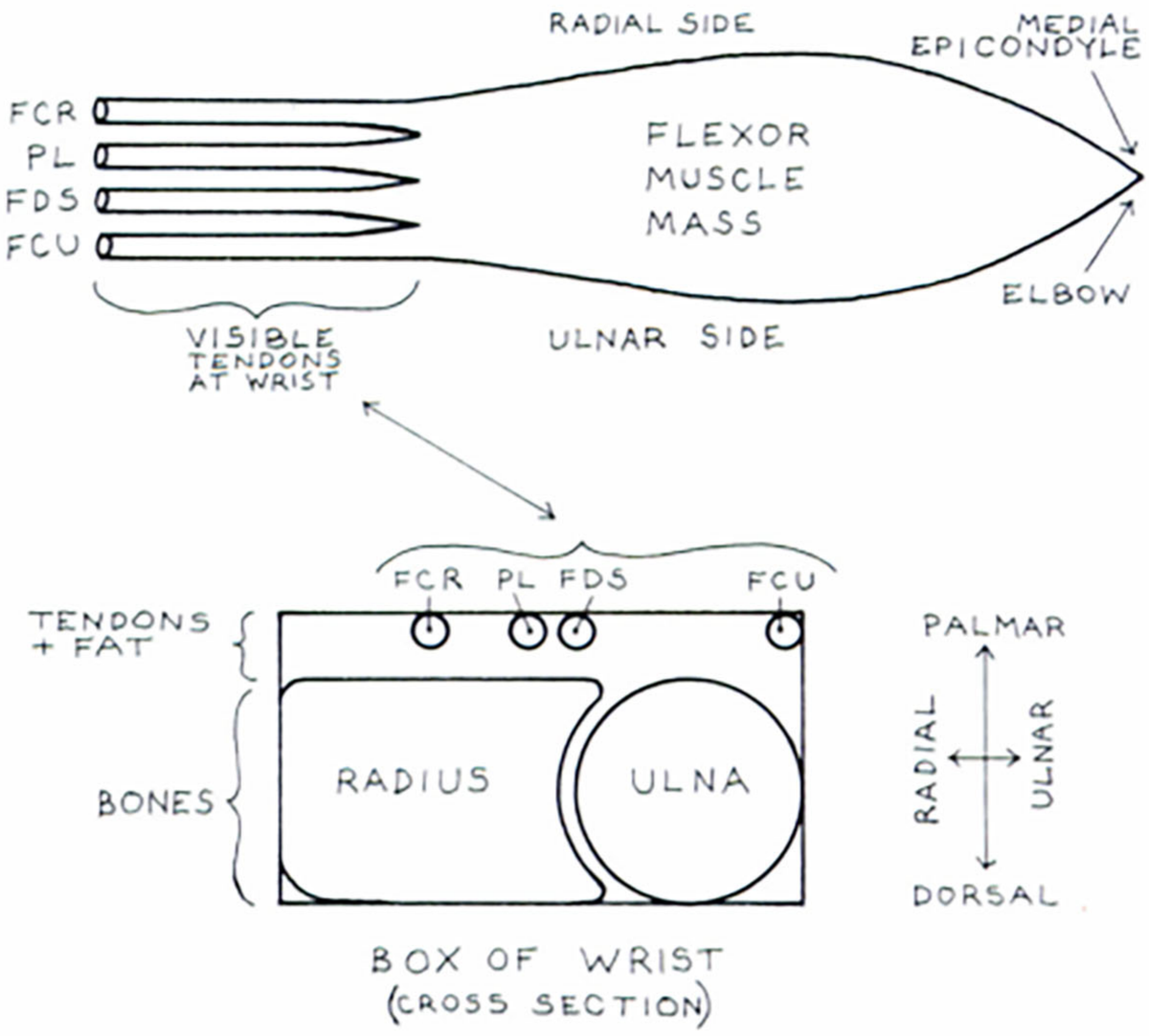
In review, in the basic simplification of the

The Forearm Muscles









Brr *Brachioradialis* ECR *Extensor carpi radialis* ECRB *Extensor carpi radialis brevis*
ECRL *Extensor carpi radialis longus* ECU *Extensor carpi ulnaris* ED *Extensor digitorum*
EPL *Extensor pollicis longus* FCR *Flexor carpi radialis* FCU *Flexor carpi ulnaris* FD *Flexor digitorum*
FDS *Flexor digitorum superficialis* PL *Palmaris longus*

muscles on the forearm, there are *three flexors* coming off the medial epicondyle (with a *short epicondyle addition*), *three extensors* coming off the lateral epicondyle (with a *short epicondyle addition*), *two ridge muscles* coming off the supracondylar ridge, plus a few *modifications*. The flexor muscles are located on the medial half of the forearm, the extensor muscles on the back of the forearm, and the ridge muscles on the outside of the forearm.

The heavy muscle mass of the lower arm is located proximally on the forearm, while its tendons are located distally. This shifts the weight of the muscles away from the region of the hand, without sacrificing strength (the total muscle volume remains the same). The hand is therefore lighter, reducing the problem of mass inertia, which makes it easier to start and stop a motion. (The same situation is found in the lower leg, but not in the upper arm or in the thigh.)

The flexor mass is larger and stronger (for flexing the wrist and fingers) than the extensor mass. Supination of the forearm is more powerful than pronation (because the powerful biceps muscle in the upper arm is the primary supinator). The extensor muscles are more defined than the flexors and can be readily identified individually.

Proximally, the individual flexor muscles attach to the **common flexor tendon,** which in turn attaches into the medial epicondyle of the humerus. The attachment of the flexors into this common tendon prevents them from becoming defined in this region.

The flexor muscles together can be visualized as a large, somewhat fusiform, elongated ovoid volume, which originates from the medial epicondyle of the humerus. Distally, the single mass sends down four visible tendons that are seen at the wrist. Starting from the radial side, the visible tendons are those of the flexor carpi radialis, palmaris longus, flexor digitorum superficialis to the ring finger, and flexor carpi ulnaris.

The upper (proximal) end of the forearm flexor mass is traversed by the **bicipital aponeurosis.** This is a bandlike, tendinous expansion that originates from the surface of the belly and tendon of the biceps brachii muscle and descends downward and backward on the surface of the flexor mass, passing a couple of inches below the medial epicondyle of the humerus. It constricts the flexor mass, creating a furrow or flatness where it lies; the flexor mass bulges both above and below the aponeurosis. The furrow is most pronounced when the forearm is supinated, the elbow joint flexed to 90°, and the biceps tensed.

In the position of supination, the entire muscular mass of the upper portion of the forearm is wider side to side and thinner front to back (oval in cross section). When pronated, these dimensions become equal as this area becomes more cylindrical (circular in cross section). The bony and tendinous wrist remains blocklike in both positions.

Because of the carrying angle at the articulation of the ulna with the humerus, when the elbow is straight and the forearm supinated, the axes of the upper arm and lower arm are not in line—the forearm angles out laterally. When the extended forearm is supinated (the radius crosses in front of the ulna), the axes of both the upper arm and forearm overall volumes lie on a single straight line.

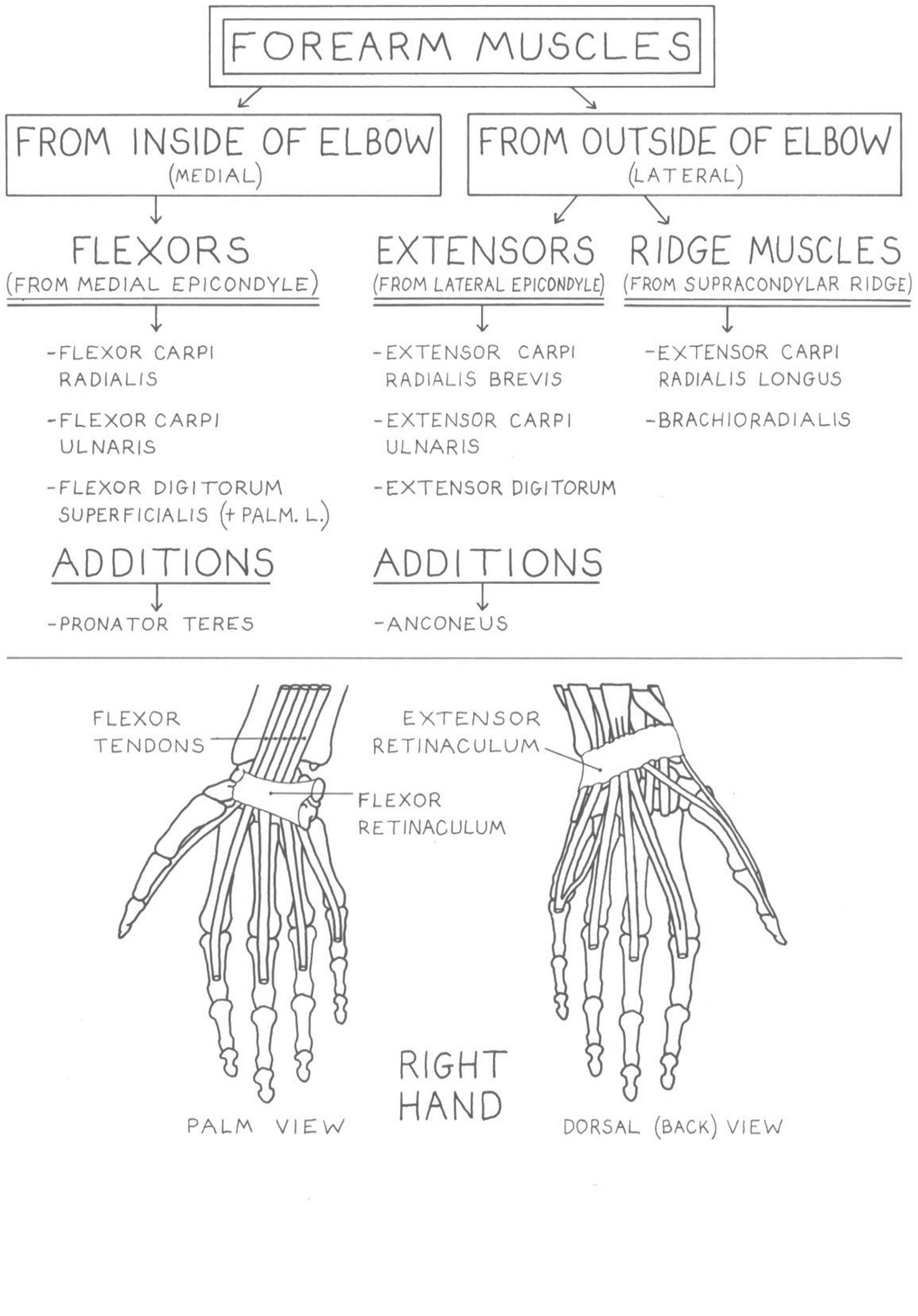
The **cubital fossa** is the small triangular interval located at the upper end of the forearm on the front of the elbow. The apex of the triangle is directed downward. The cubital fossa is bordered by the pronator teres medially, the brachioradialis laterally, and the brachialis and biceps tendon superiorly. This interval is filled with fat and is not seen in the straight arm. At other times it may register as a subtle depression, best seen when the elbow is flexed to almost 90°, the forearm pronated, and the muscles tensed.

As previously mentioned, the region of the wrist is basically blocklike (rectangular in cross section). It is approximately twice as wide as it is deep. The radius and ulna form the hard bony back and sides of the box, while the flexor tendons, intervening wrist fat, and some muscle fibers form the anterior side of the box. The anterior side becomes less planar as the tendons are contracted and rise away from the surface. The prominent head of the ulna forms the inner back corner of the box, and the tendon of the flexor carpi ulnaris forms the inner front corner.

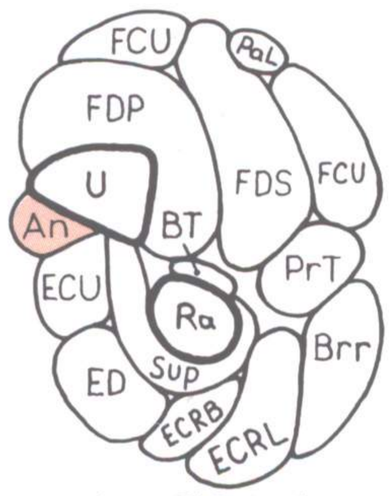
The deep fascia of the distal end of the forearm thickens into a band that cuffs the entire wrist and holds the tendons against it. Additional thickening of this fascia on the back of the wrist forms the **extensor retinaculum.** The slightly oblique extensor retinaculum attaches to the styloid process of the ulna and the triquetral and pisiform bones of the carpus *medially* and to the lateral edge of the radius *laterally*. Crossing the back of the wrist, it adheres to the ridges on the back of the distal end of the radius, forming tunnels for the passage of the extensor tendons. The extensor retinaculum is not seen directly, and it conceals the forms of the tendons it covers. The tendons become very conspicuous as soon as they emerge distally.

The **flexor retinaculum** is a deep, thick, fi-

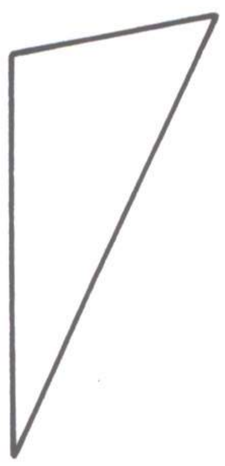
The Forearm Muscles



brous band that spans across the concave palmar aspect of the carpus, creating the **carpal tunnel** for passage of the long flexor tendons of the fingers. The flexor retinaculum attaches to the pisiform and hamate *medially* and to the scaphoid and trapezium *laterally*. Its anterior surface provides attachment area for some of the thenar and hypothenar muscles of the hand, placing this retinaculum deep to these hand muscle bellies (the extensor retinaculum is superficial). The apex of the superficial palmar aponeurosis attaches to the flexor retinaculum (see Hand Muscles).



SECTION A



Anconeus

ORIGIN By its own separate tendon from the bony surface *behind* and *inferior to* the lateral epicondyle of the humerus.

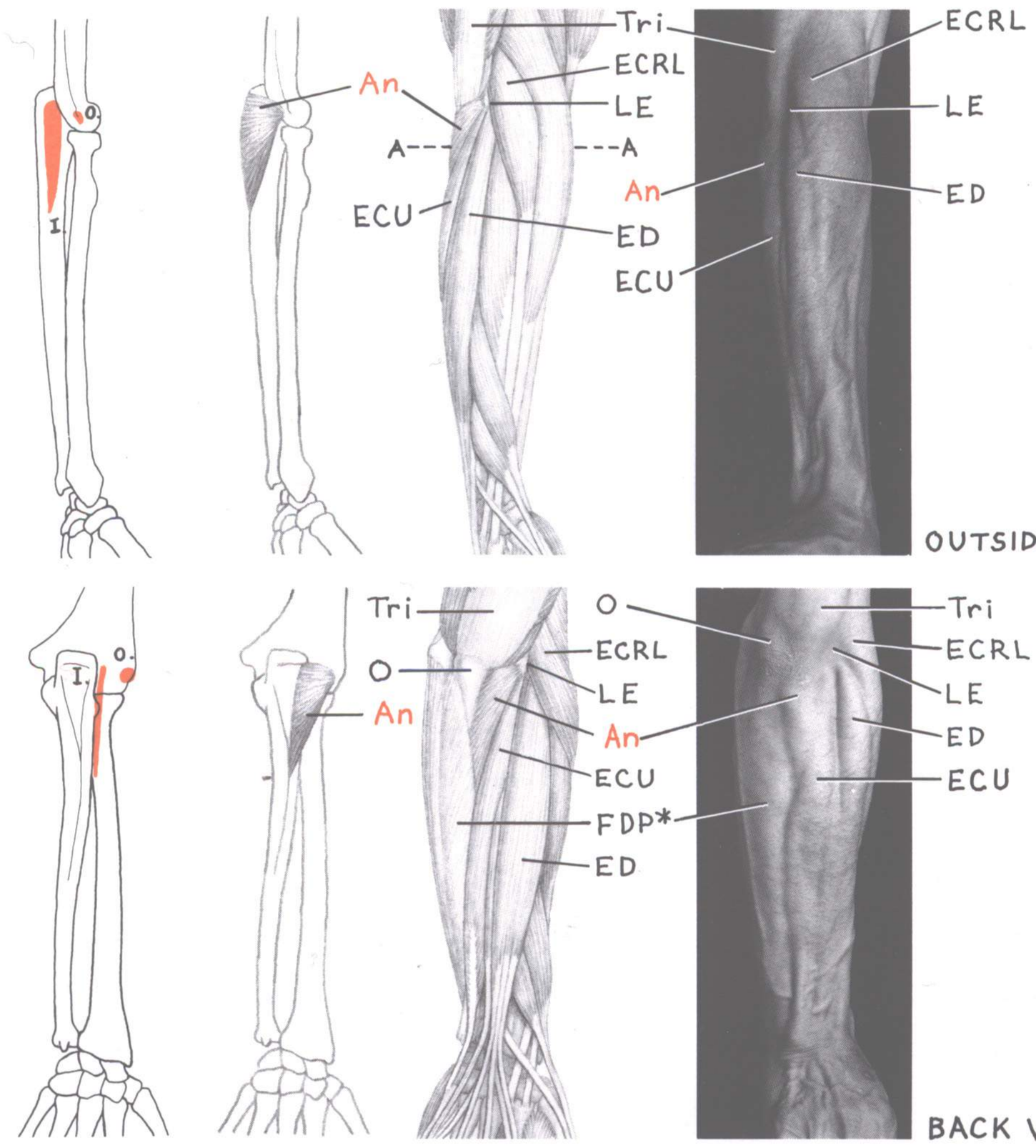
INSERTION Lateral surface of the olecranon, continuing down the upper fourth of the posterolateral surface of the ulna.

ACTION Extends and stabilizes the elbow joint.

STRUCTURE The anconeus is a small triangular muscle located on the outer back corner of the elbow, below the elbow joint. It fills the space between the lateral epicondyle and olecranon and then continues one-fourth of the way down the forearm. Its belly is sharply pointed inferiorly. The anconeus does not cover the head of the radius.

When the elbow joint is fully extended, the anconeus creates a distinct, bulging, low relief, quite separate from the forms of the triceps and the muscles originating from the lateral epicondyle of the humerus. The anconeus flattens as the elbow is flexed. The posterior edge of the upper half of its insertion is in contact with the ulna, while its lower half lies up against the flexor muscles of the forearm. The upper edge of the anconeus is in contact with the medial head of the triceps.

Aponeurotic fibers from the lateral edge of the triceps tendon continue downward onto the surface of the anconeus. These tendinous fibers may affect its form by creating a furrow or by producing a ridge.



An *Anconeus* **ECRL** *Extensor carpi radialis longus* **ECU** *Extensor carpi ulnaris*
ED *Extensor digitorum* **FDP** *Flexor digitorum profundus* **LE** *Lateral epicondyle* **O** *Olecranon*
Ra *Radius* **Tri** *Triceps* **U** *Ulna* * *Under flexor carpi ulnaris*

Extensor Digitorum (Extensor Digitorum Communis)

ORIGIN lateral epicondyle of the humerus (by the common extensor tendon).

INSERTION Dorsal aspect of the middle and distal phalanges of fingers two through five. It does not insert into the thumb.

ACTION Extends all the joints of fingers two through five, especially the metacarpophalangeal joints. By continued action, it extends the wrist.

STRUCTURE The extensor digitorum is the widest of the lateral epicondyle muscle group. At its origin, its belly is the most prominent of this group. The belly is flat and fusiform. Toward the lower half of the forearm the muscle develops four tendons. The tendons add very little thickness to the back of the wrist, keeping the back of the wrist flat and planar. Since this muscle is actually a group of four muscles and their tendons, when fingers two through five are individually moved, the belly to each individual finger can be seen working independently on the forearm. The divergence of the tendons on the back of the hand is greater than that of the underlying metacarpal bones. This relationship is especially noticeable between the tendon and the metacarpal of the index finger.

Just past the metacarpophalangeal joint, each tendon expands into the **dorsal extensor aponeurosis** (extensor hood, extensor expansion, dorsal digital expansion), which is an aponeurotic expansion of the tendon of the extensor digitorum that begins on, and then covers, the dorsal aspect of the proximal phalanx. This aponeurosis soon splits, sending tendinous slips directly into the bases of the middle and distal phalanges. It receives the tendinous insertions of the interossei and lumbrical muscles. The dorsal extensor aponeurosis and the tendinous slips are not seen in life.

The **extensor indicis** originates, and is located, deep in the forearm. Only its tendon is superficial on the back of the hand, occasionally becoming visible as it descends along the ulnar side of the tendon of the extensor digitorum to the index finger. This muscle *originates* from a small area on the lower third of the back of the ulna and adjacent interosseous membrane and *inserts* into the extensor hood of the index finger, along with the tendon of the extensor digitorum to that finger. Its *function* is to extend and also to adduct the index finger.

The **extensor digiti minimi** (extensor digiti quinti proprius) is a very slender muscle, closely associated with the extensor digitorum. It is often distinctly visible, lying between the extensor digitorum and extensor carpi ulnaris. Although also *originating* from the lateral epicondyle of the humerus, the superior end of the belly does not become visible until one-third of the way down the forearm. At the wrist, it develops a double tendon which *inserts* into the extensor hood of the little finger, along with the tendon of extensor digitorum to that finger. Its *function* is to extend the little finger. The double tendon of the extensor digiti minimi, not the tendon of the extensor digitorum, is usually the prominent tendon to the little finger.

Tendons on the Back of the Hand

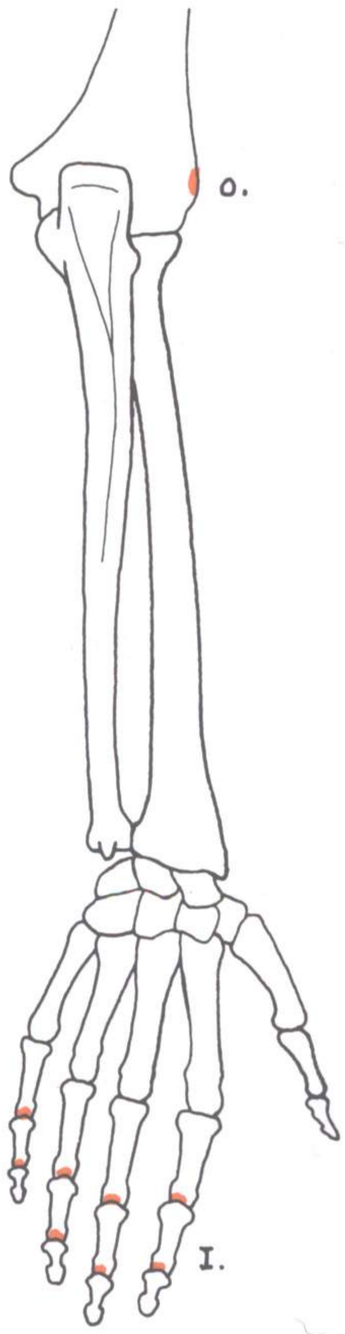
At its simplest, fingers two through five each receive one *visible* tendon, most noticeable when the fingers are extended at the metacarpophalangeal joints and flexed at the interphalangeal joints (clawed hand). The tendons of the extensor digitorum to the index, middle, and ring fingers, and the double tendon of the extensor digiti minimi to the little finger, become prominent—each shows up as a single, raised, cordlike relief directed toward its respective finger. Anatomically, however, the tendinous configuration on the back of the hand is more complex, and more than one tendon may show up per finger.

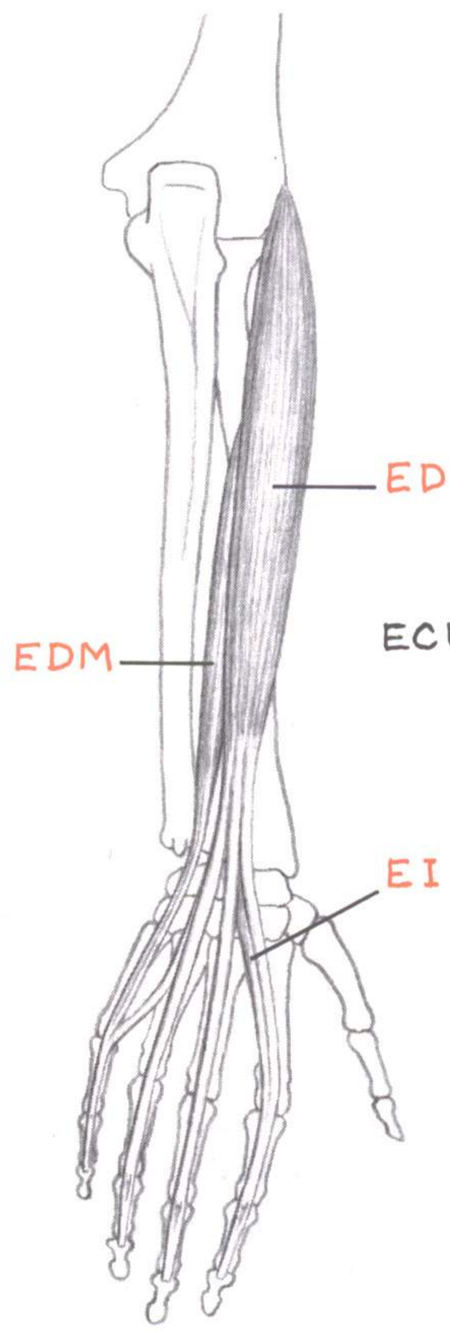
Each of the four tendons of the extensor digitorum actually each consists of several layers. More often than not, they appear as a single unit. But when some fingers are flexed and others extended, the various layers may become visible as they slide apart.

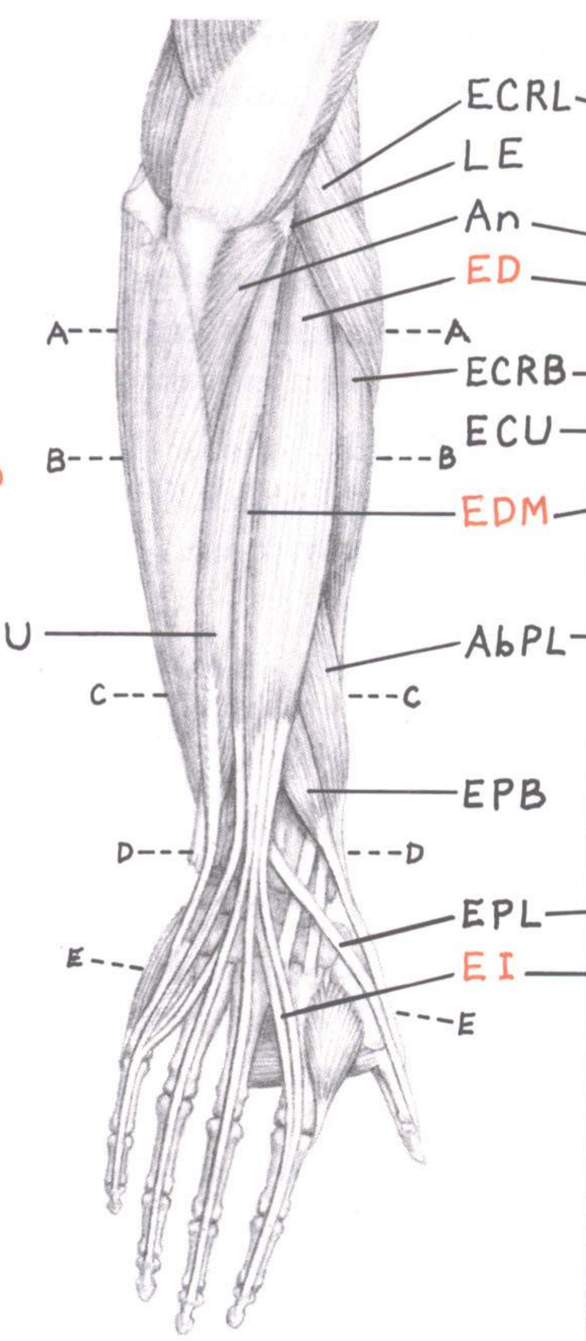
The tendon of the extensor digitorum to the little finger is not conspicuous, and usually lies next to, or partially under, the tendon of the ring finger. It occasionally becomes visible on the back of the hand between the tendon of the extensor digitorum of the ring finger and the tendon of the extensor digiti minimi of the little finger. Distally, it becomes very prominent just proximal to the head of the metacarpal, as it hooks over toward the little finger. This portion appears as a short, oblique, curved, sharp relief, easily seen moving when the little finger is flexed and extended at the metacarpophalangeal joint. The little finger therefore receives a total of three tendons: one from the extensor digitorum (a layered tendon) and the two more direct tendons from the extensor digiti minimi. Sometimes all three are visible. The double tendon of the extensor digiti minimi is separated slightly from the other finger tendons on the back of the hand.

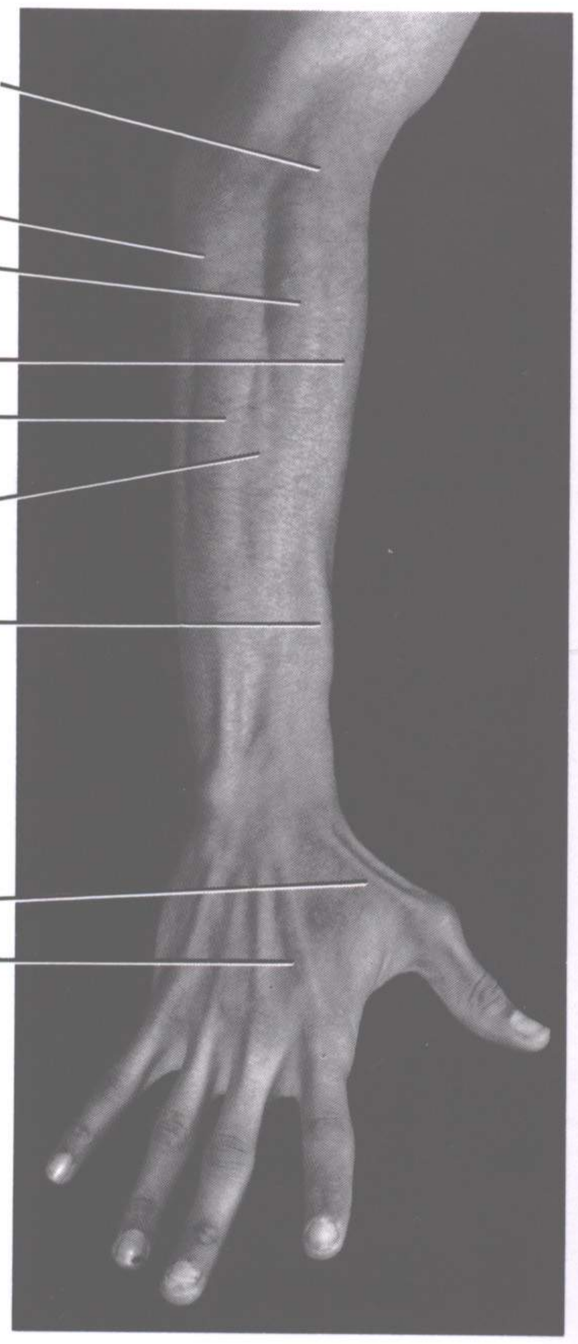
The index finger receives two tendons: one from the extensor digitorum, which is always seen, and one from the extensor indicis, which is seen occasionally.

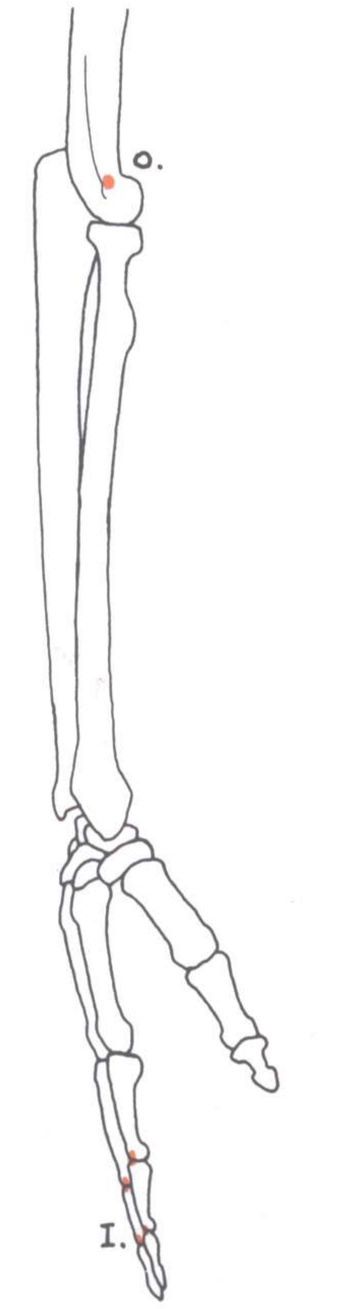
Three oblique **intertendinous connections** attach between the four tendons of the extensor

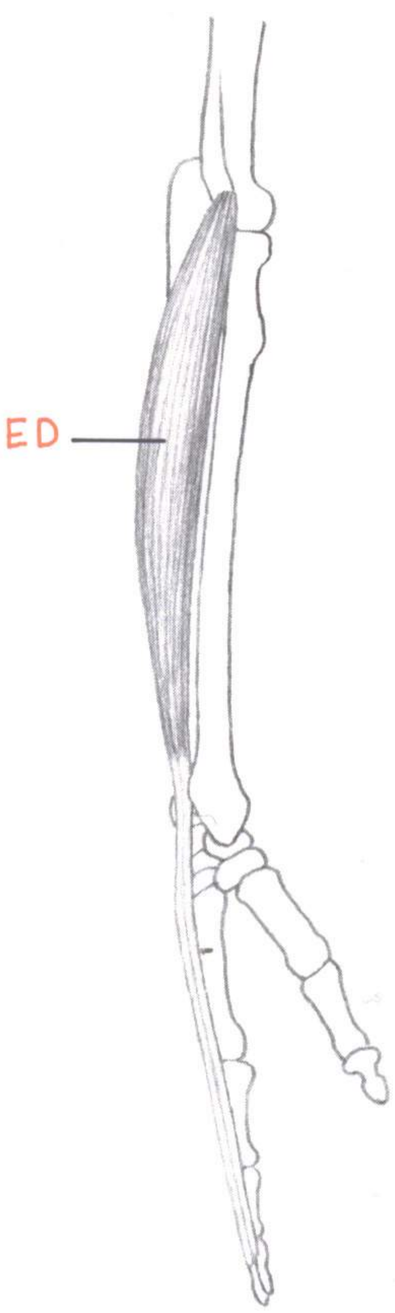


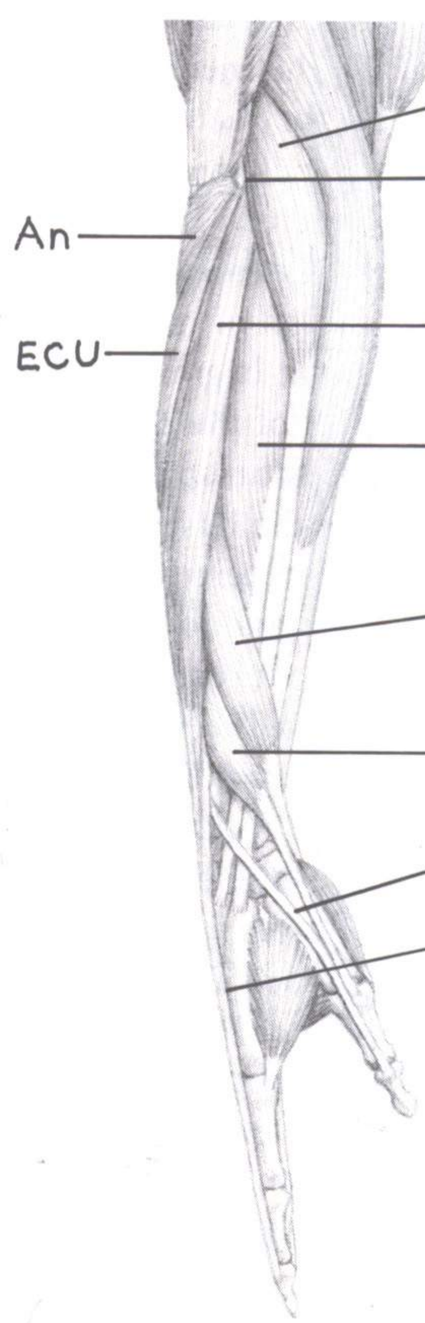


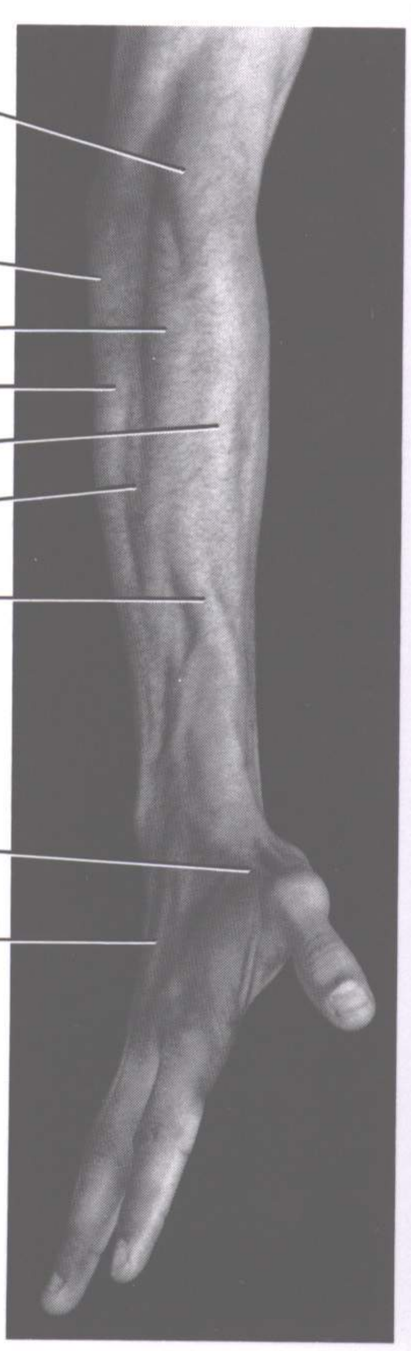




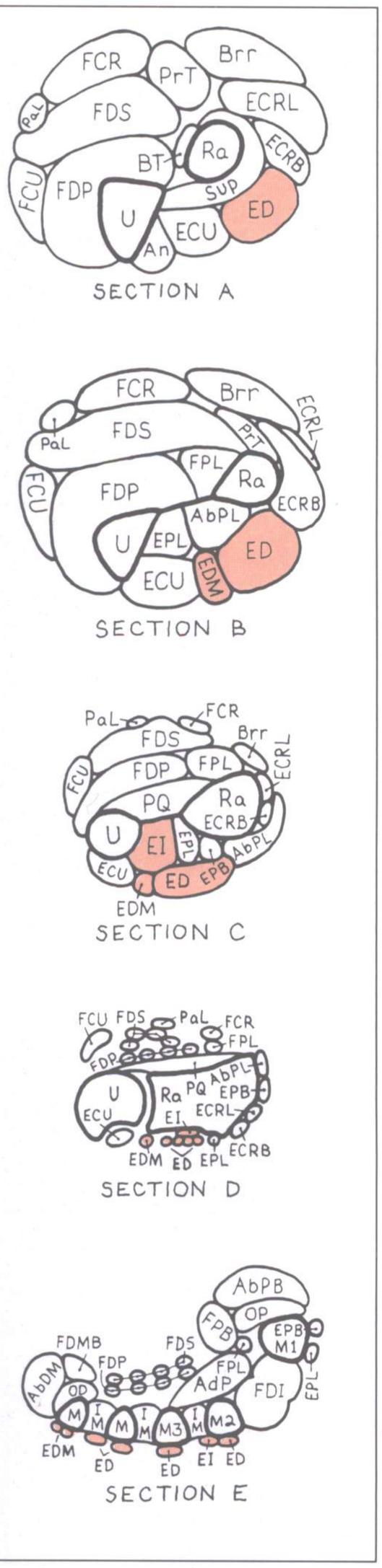






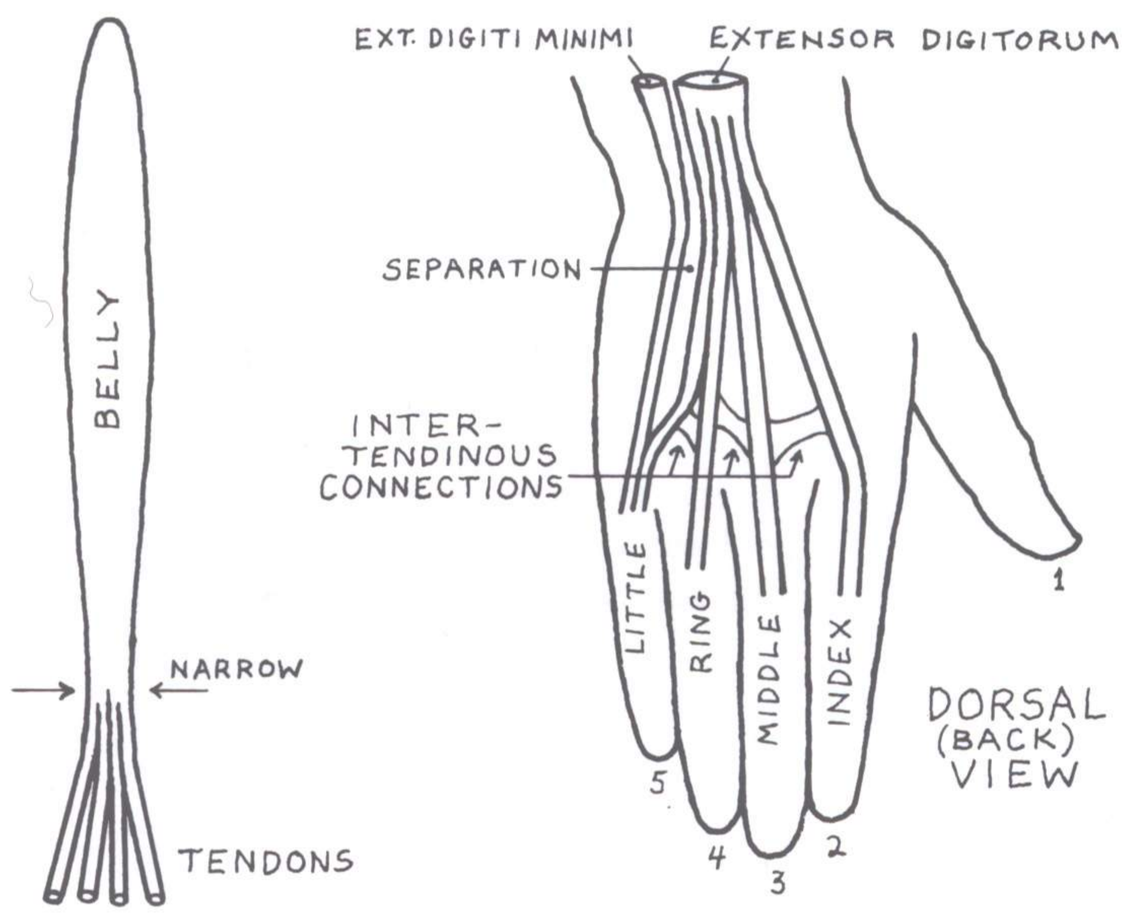


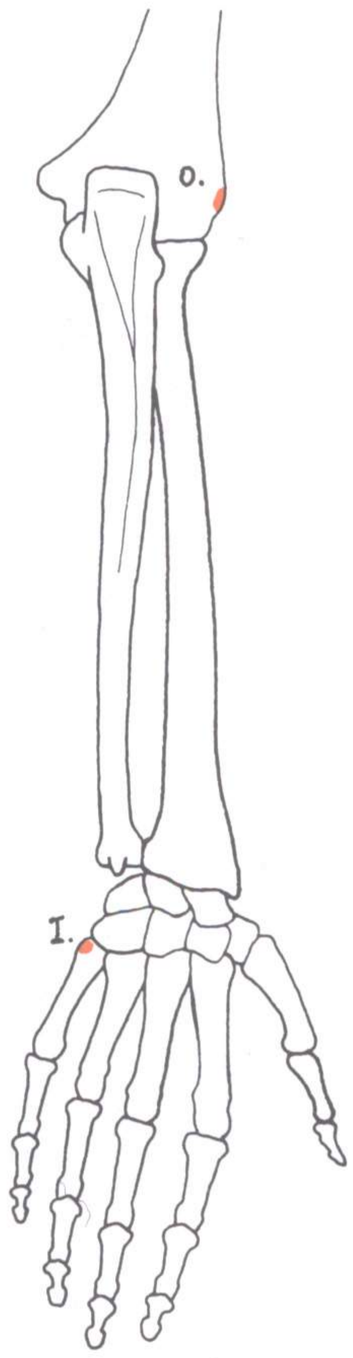
AbPL *Abductor pollicis longus* **An** *Anconeus* **ECRB** *Extensor carpi radialis brevis*
ECRL *Extensor carpi radialis longus* **ECU** *Extensor carpi ulnaris* **ED** *Extensor digitorum*
EDM *Extensor digiti minimi* **EI** *Extensor indicis* **EPB** *Extensor pollicis brevis*
EPL *Extensor pollicis longus* **IM** *Interosseous muscle* **LE** *Lateral epicondyle* **M** *Metacarpal*
Ra *Radius* **Sup** *Supinator* **U** *Ulna*

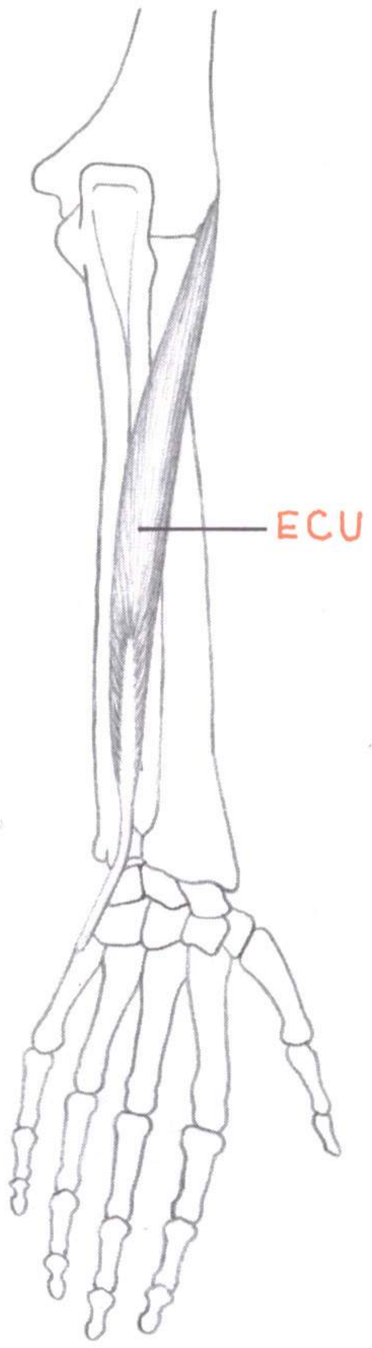


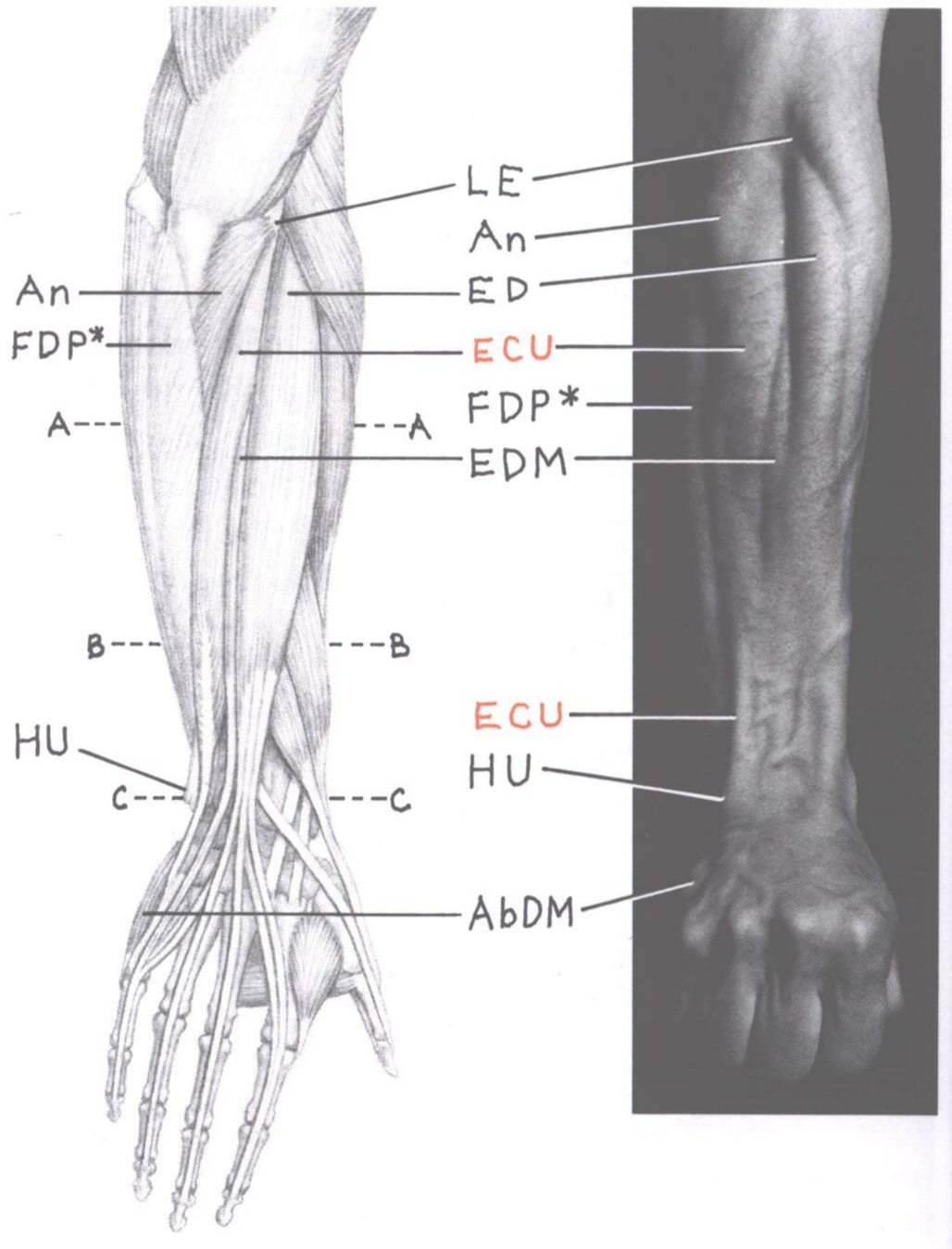
digitorum, just proximal to the heads of the metacarpals, on the back of the hand. They limit *full* extension of one finger when an adjacent finger is flexed and conversely limit flexion of one finger when an adjacent finger is extended. The intertendinous connections are thin, wide, and flat and are rarely seen directly. Because the tendons of the extensor digitorum are layered, the intertendinous connections will pull the various layers of these tendons sideways when the fingers are flexed and extended. This reveals the layers, especially those of the middle, ring, and little fingers.

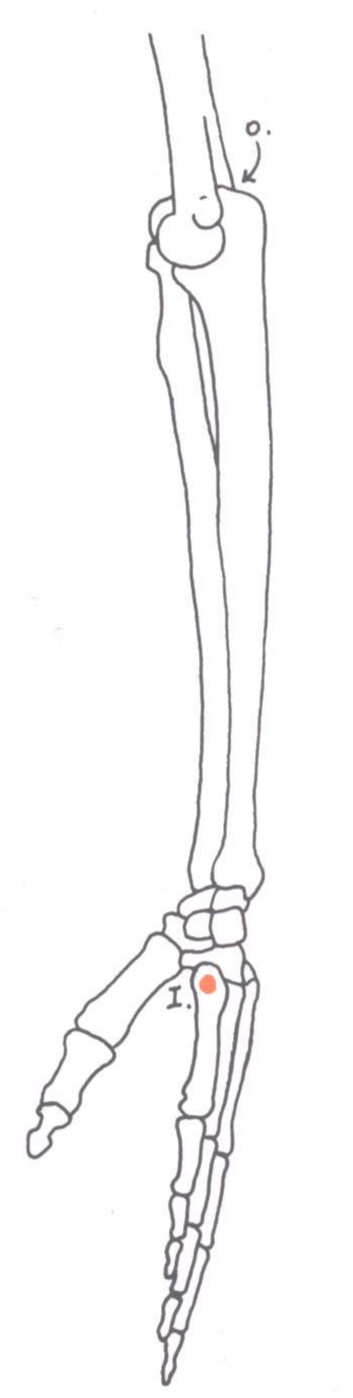
When making a fist, the tendons become dull crests on the rounded ends of the heads of the metacarpal bones. When the fingers are extended, the tendons disappear from view about one-third to one-half of the way down the back of the proximal phalanges, as they flatten into the dorsal extensor aponeurosis. The tendon to the index finger can occasionally be traced all the way down to the proximal interphalangeal joint.

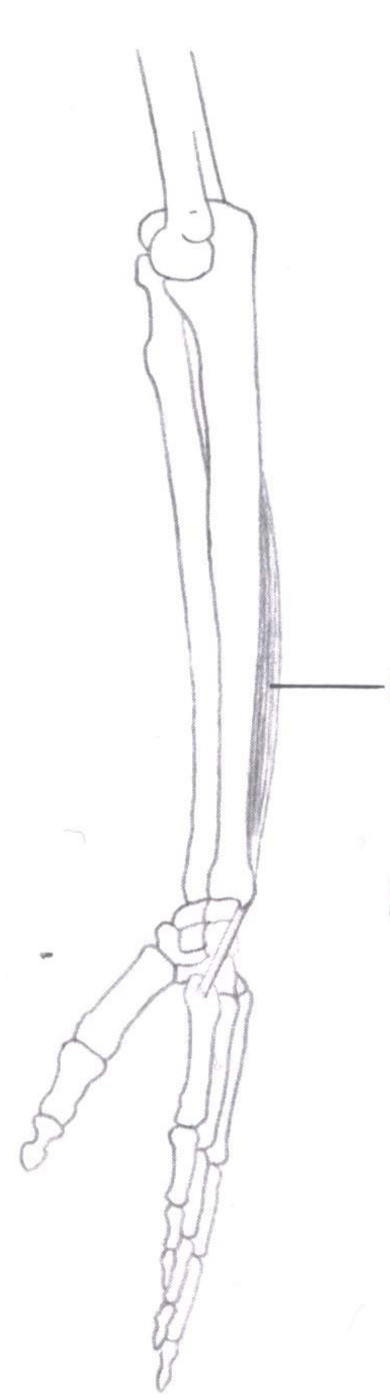


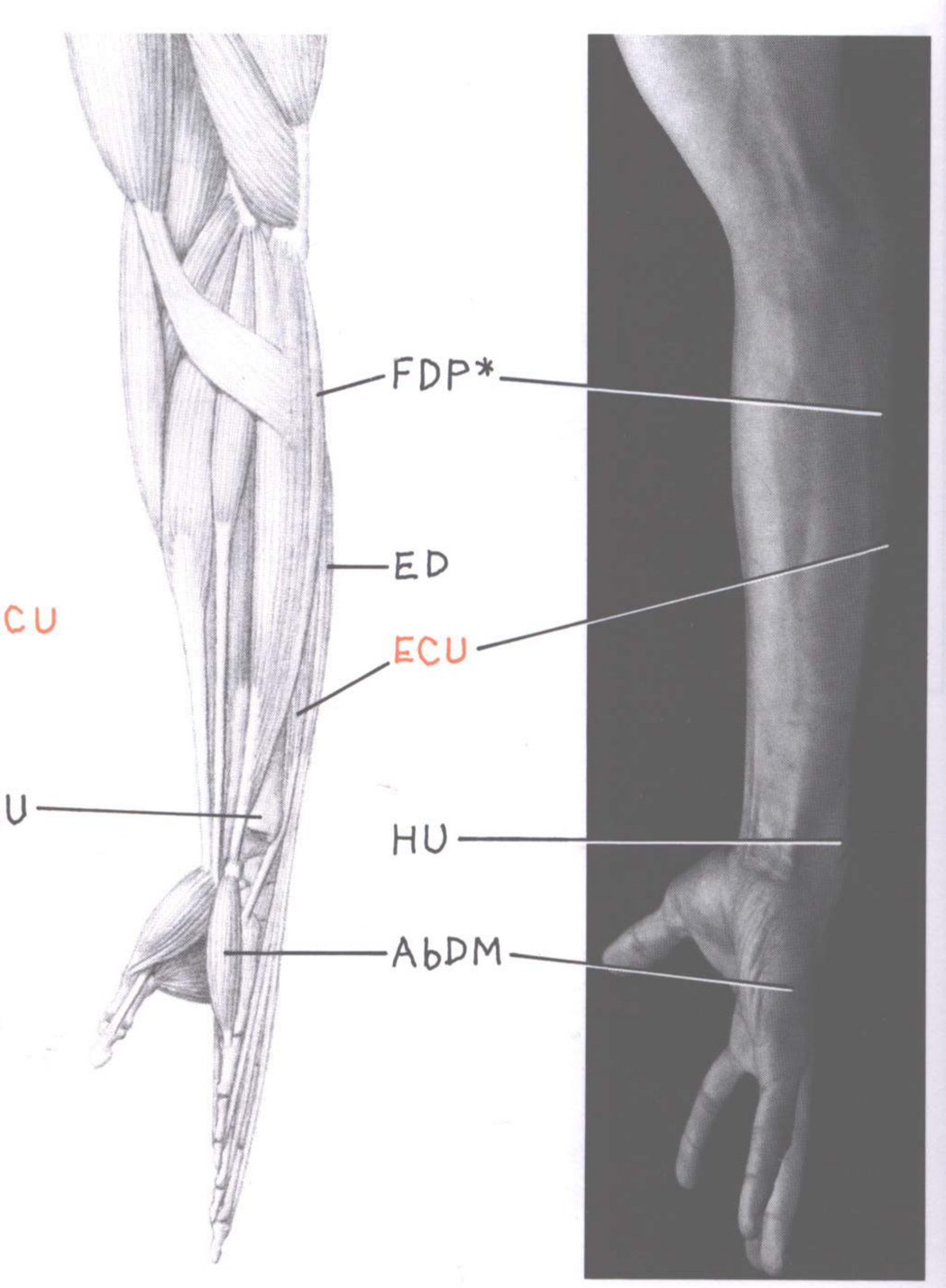




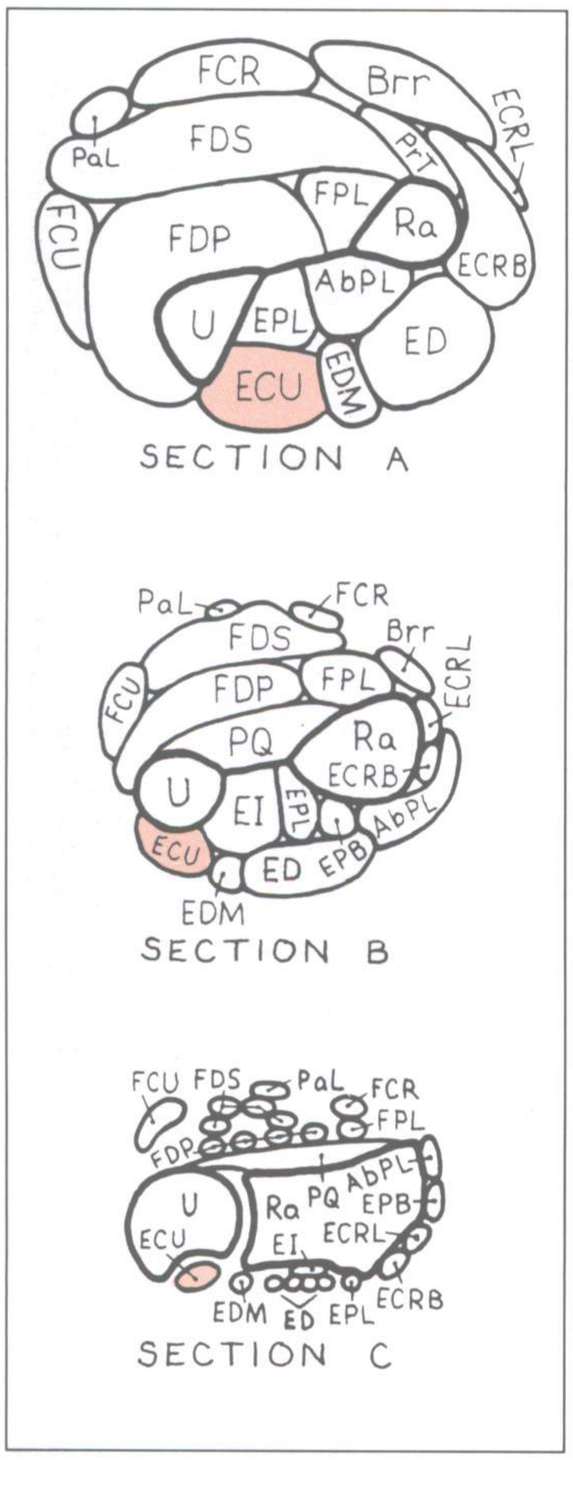








AbDM *Abductor digiti minimi* **An** *Anconeus* **ECU** *Extensor carpi ulnaris* **ED** *Extensor digitorum*
EDM *Extensor digiti minimi* **EI** *Extensor indicis* **EPL** *Extensor pollicis longus*
FDP *Flexor digitorum profundus* **HU** *Head of ulna* **LE** *Lateral epicondyle* **Ra** *Radius* **U** *Ulna*
* *Under flexor carpi ulnaris*



Extensor Carpi Ulnaris

ORIGIN Lateral epicondyle of the humerus (by the common extensor tendon), and by an aponeurosis along the upper two-thirds of the posterior border of the ulna.

INSERTION Tubercle on the outer surface of the base of the fifth metacarpal bone (of the little finger).

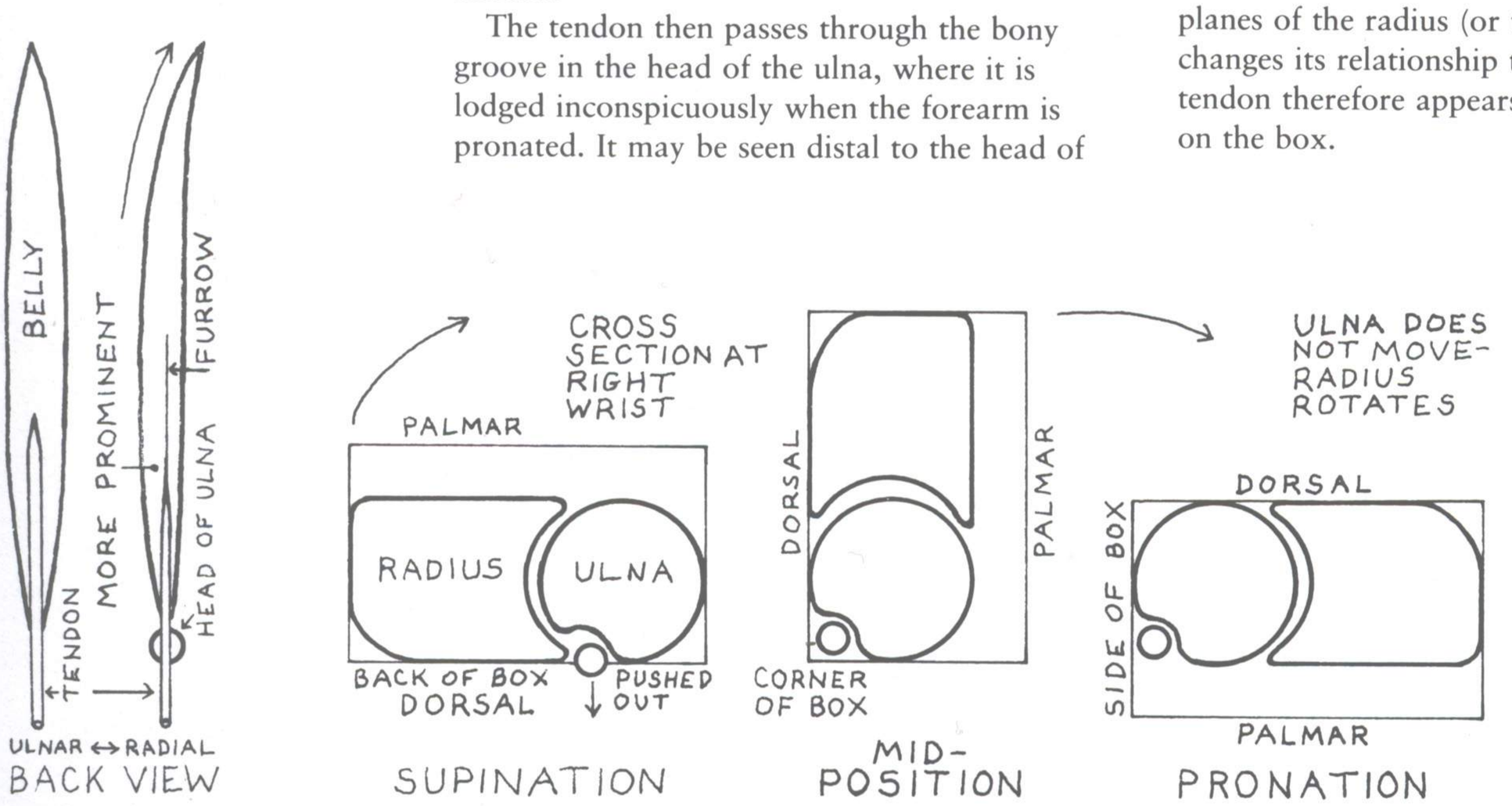
ACTION Extension and ulnar deviation of the hand at the wrist joint.

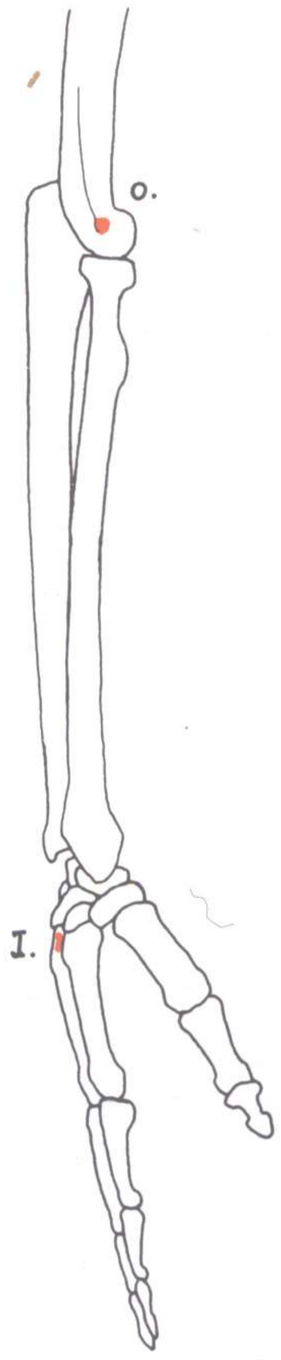
STRUCTURE The extensor carpi ulnaris is a narrow, elongated, flattened muscle, whose overall axis curves toward the ulna between its proximal and distal points of attachment. On the back of the middle third of the forearm, the extensor carpi ulnaris and forearm flexor muscles are separated by a groove, at the bottom of which lies the posterior border of the ulna.

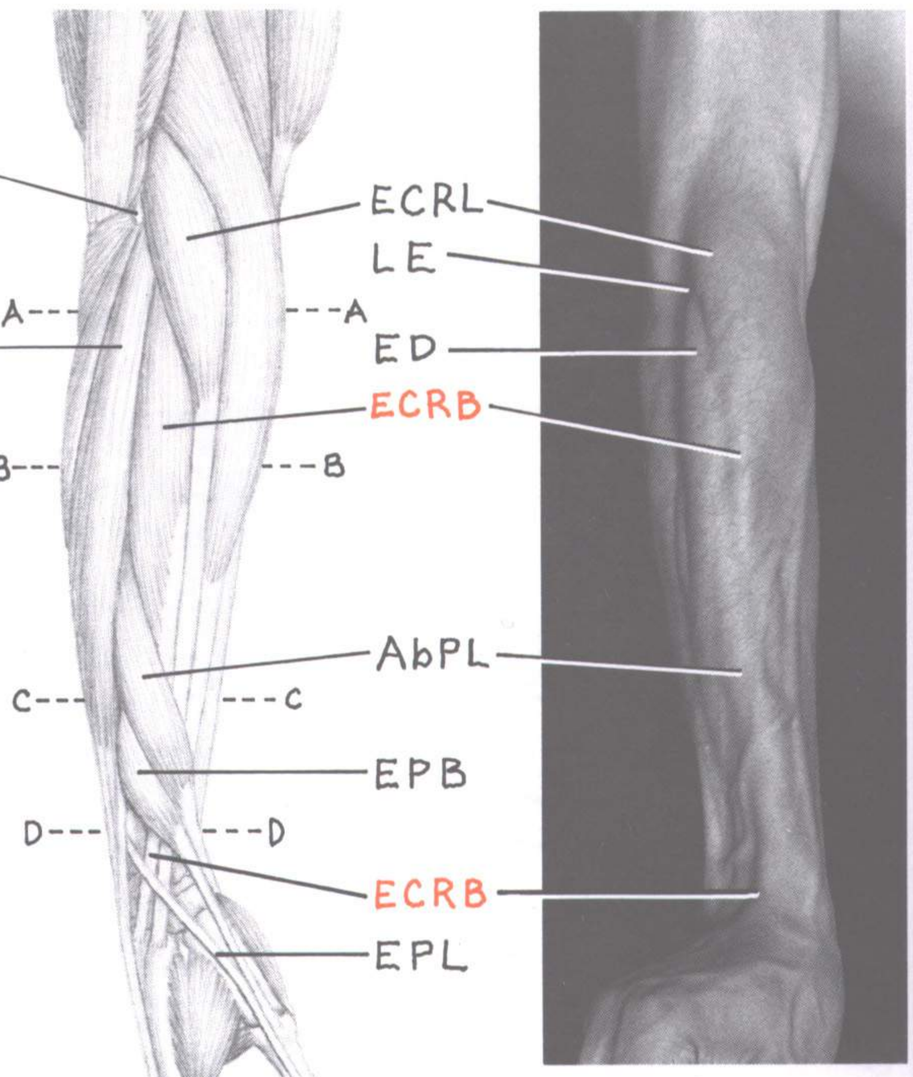
The tendon of the extensor carpi ulnaris begins three-fourths of the way down the forearm. The muscle fibers continue down each side of the tendon, almost all the way down to the head of the ulna. The muscle and tendon may show up as a single elongated form, or the lower muscular portion may split into two elongated, parallel forms (the tendon appears recessed as a furrow). Distally, before reaching the wrist, the tendon may appear raised on the surface.

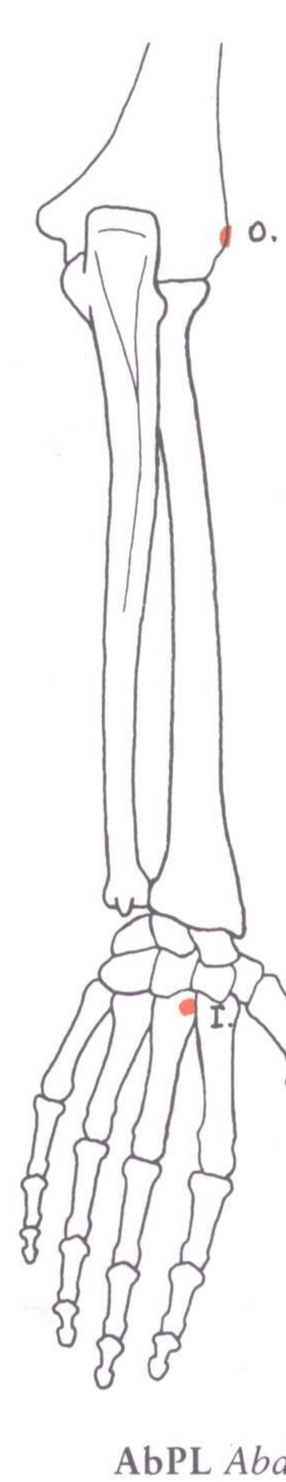
The tendon then passes through the bony groove in the head of the ulna, where it is lodged inconspicuously when the forearm is pronated. It may be seen distal to the head of the ulna on the outer corner of the wrist as it crosses the wrist joint. The tendon becomes prominent at, above, and below the head of the ulna when the forearm is supinated. It becomes prominent during supination because the tendon is pulled slightly out of the bony groove in the head of the ulna by the rotation of its insertion point on the hand away from the head of the ulna (the ulna stays fixed and the hand rotates along with the radius during supination).

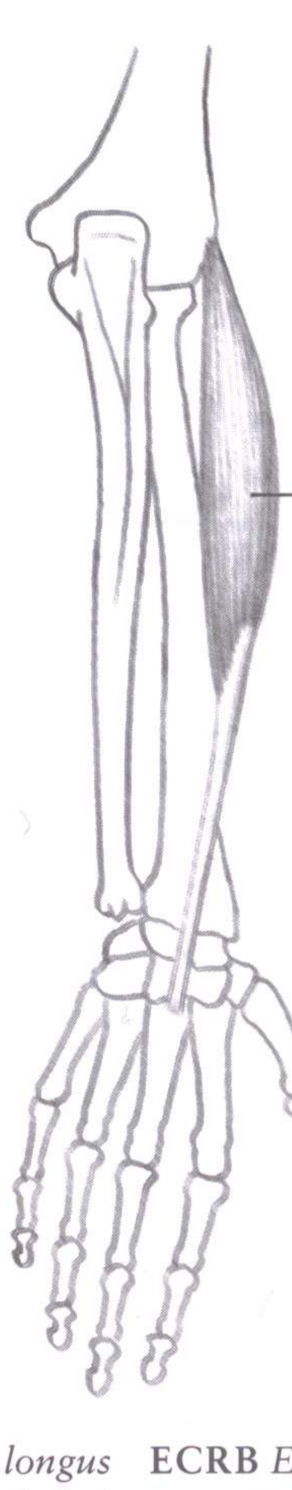
The wrist can be visualized as a box. When the forearm is pronated, the tendon of the extensor carpi ulnaris lies inconspicuously in the notch of the head of the ulna, on the ulnar *side of the box* of the wrist. During full supination, the tendon becomes raised and conspicuous and is located on the *back of the box* of the wrist. In the middle position of pronation/supination, the tendon is located in the actual *corner of the box* of the wrist, again lying inconspicuously within the notch of the head of the ulna. This shifting of the tendon relative to the box of the wrist occurs because during pronation and supination, the distal end of the radius (which is responsible for forming two planes of the box) rotates around the fixed (nonmoving) head of the ulna. Since the relationship of the tendon to the head of the ulna is also fixed (lodged in the notch), as the radius rotates it exposes different surface areas of the head of the ulna. The planes of the radius (or the surface of the box) changes its relationship to the tendon, and the tendon therefore appears in different locations on the box.

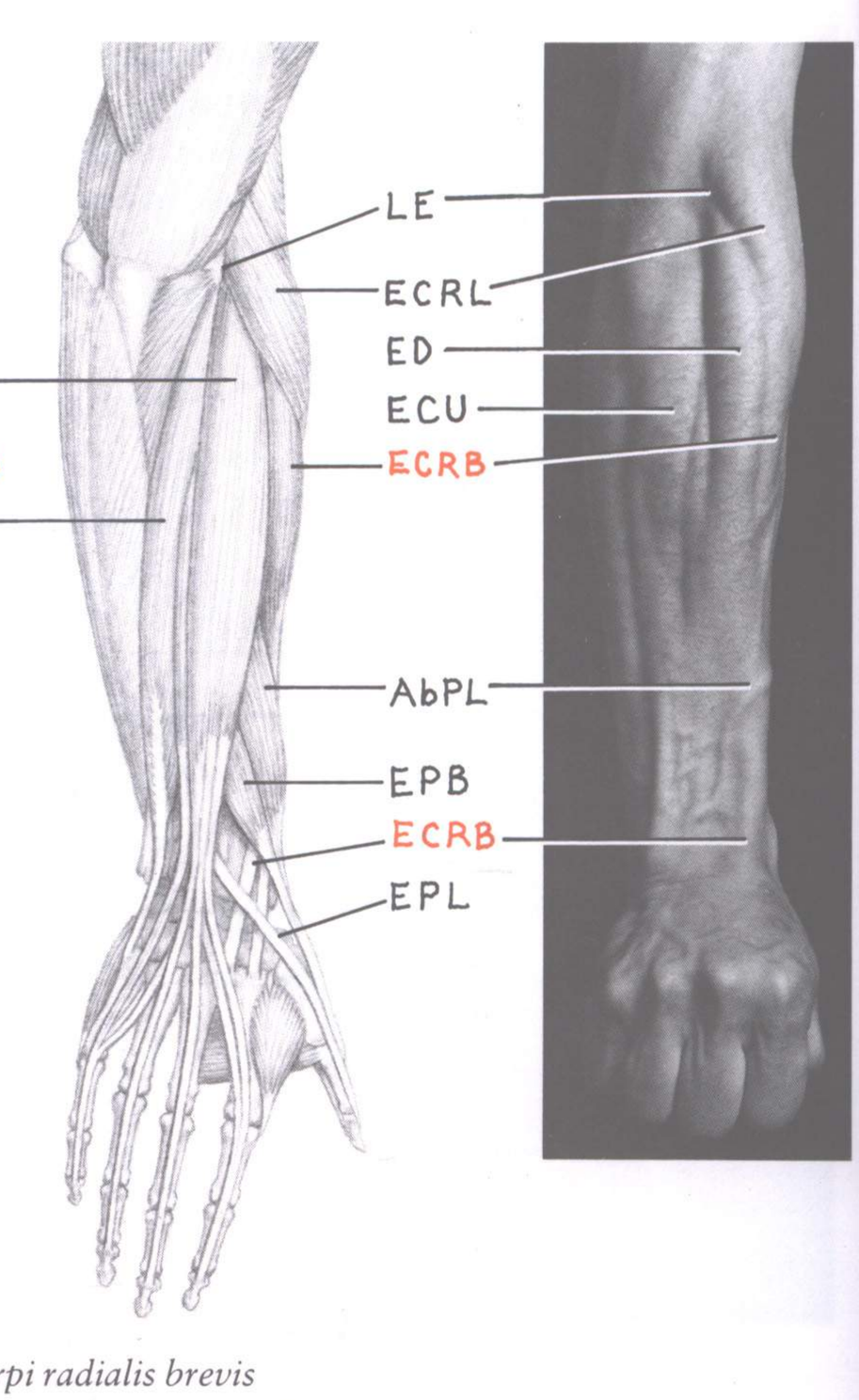




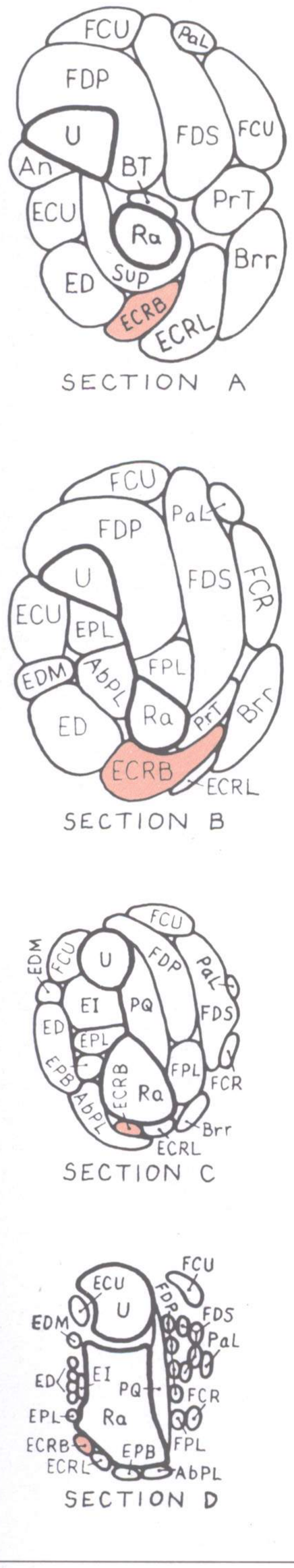








AbPL *Abductor pollicis longus* **ECRB** *Extensor carpi radialis brevis*
ECRL *Extensor carpi radialis longus* **ECU** *Extensor carpi ulnaris* **ED** *Extensor digitorum*
EPB *Extensor pollicis brevis* **EPL** *Extensor pollicis longus* **LE** *Lateral epicondyle* **PrT** *Pronator teres*
Ra *Radius* **Sup** *Supinator* **U** *Ulna*



Extensor Carpi Radialis Brevis

ORIGIN Lateral epicondyle of the humerus (by the common extensor tendon) and the radial collateral ligament of the elbow joint.

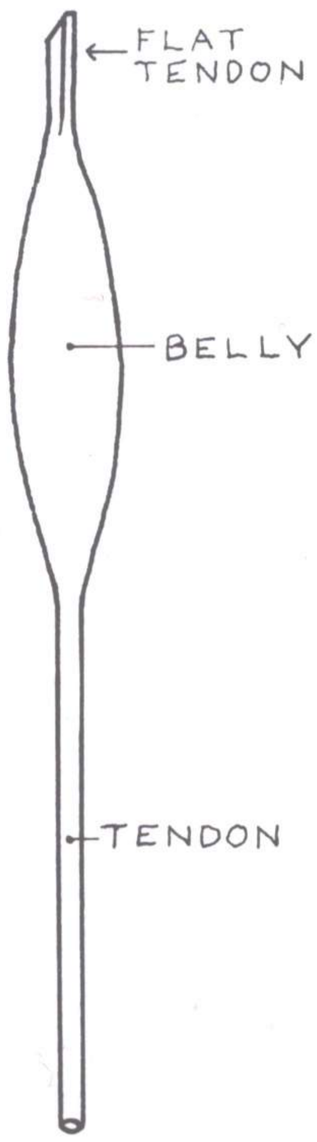
INSERTION Dorsal surface of the base of the metacarpal bone of the middle finger, toward its radial side.

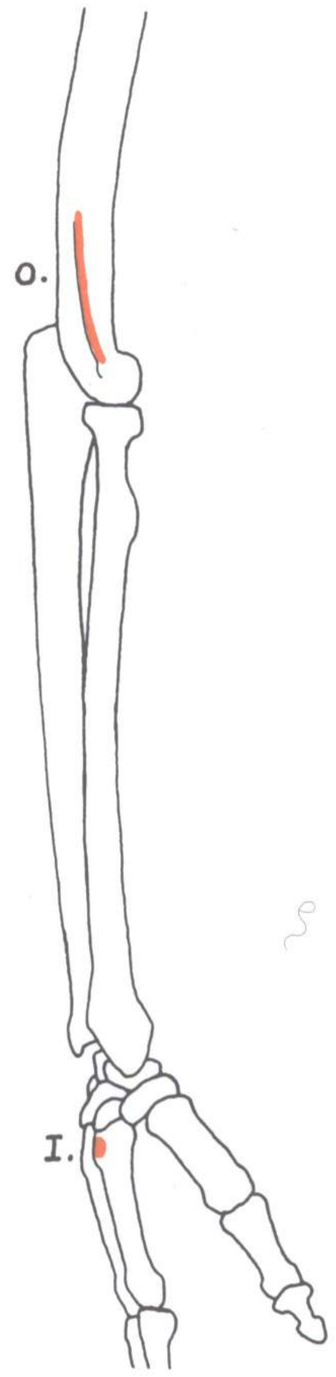
ACTION Extends and radially deviates the hand at the wrist joint.

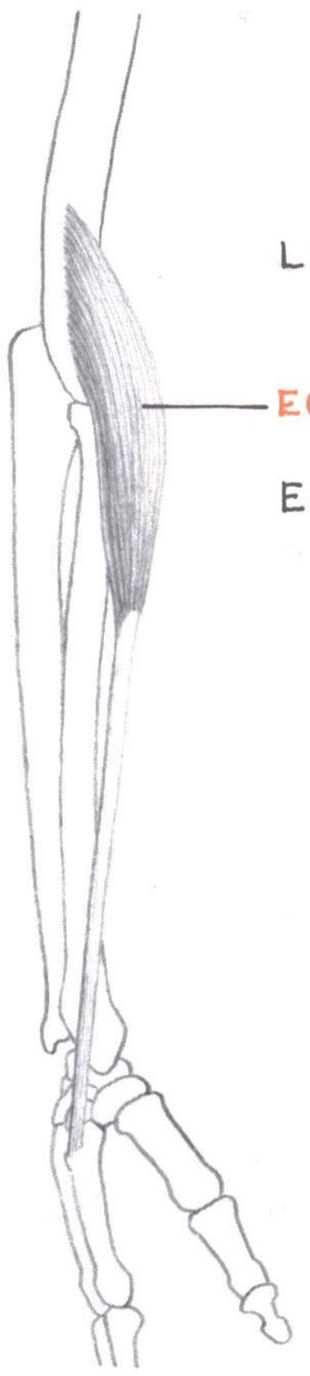
STRUCTURE The extensor carpi radialis brevis begins proximally at the lateral epicondyle as a short, wide, flattened tendon compressed between the bellies of the extensor carpi radialis longus and extensor digitorum; its fleshy fibers, and therefore its form, do not begin at its origin at the lateral epicondyle. It soon expands into a thick fusiform belly located on the outer surface of the radius. Its fibers end halfway to two-thirds of the way down the forearm into a long, narrow, flat tendon. The belly of the extensor carpi radialis brevis therefore shows up as a well-defined fusiform relief on the extensor side of the forearm, beginning a couple of inches *below* the elbow joint and ending just below the middle of the forearm. The belly appears to "float" longitudinally in this region of the forearm, reaching neither the elbow nor the wrist, as the other epicondyle extensors do. The axis of the belly runs parallel to the long axis of the forearm. The belly is more prominent during supination (with the wrist extended) than during pronation.

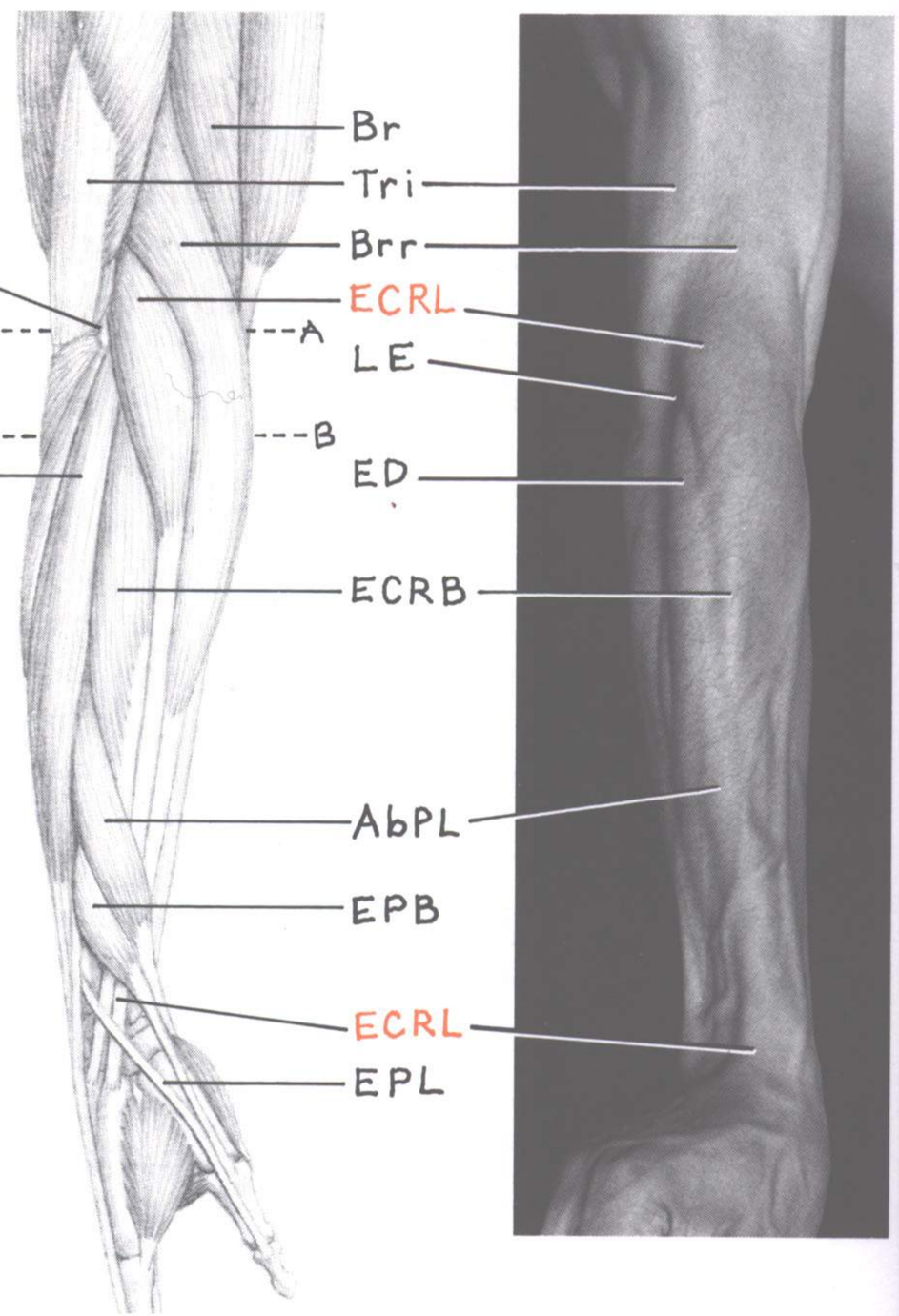
The tendon of the extensor carpi radialis brevis, beginning on the radial side of its belly, travels down the forearm next to the tendon of the extensor carpi radialis longus and passes down the middle of the back surface of the lower end of the radius in its own bony groove. Together, the tendons of extensors carpi radialis longus and brevis, barely visible as a single linear ridge on the lower half of the forearm when the wrist is extended, pass under the abductor pollicis longus and extensor pollicis brevis. At the point where they cross the wrist joint at the end of the radius, they create a small, separate, transitional plane between the back of the wrist and the back of the hand when the wrist is extended.

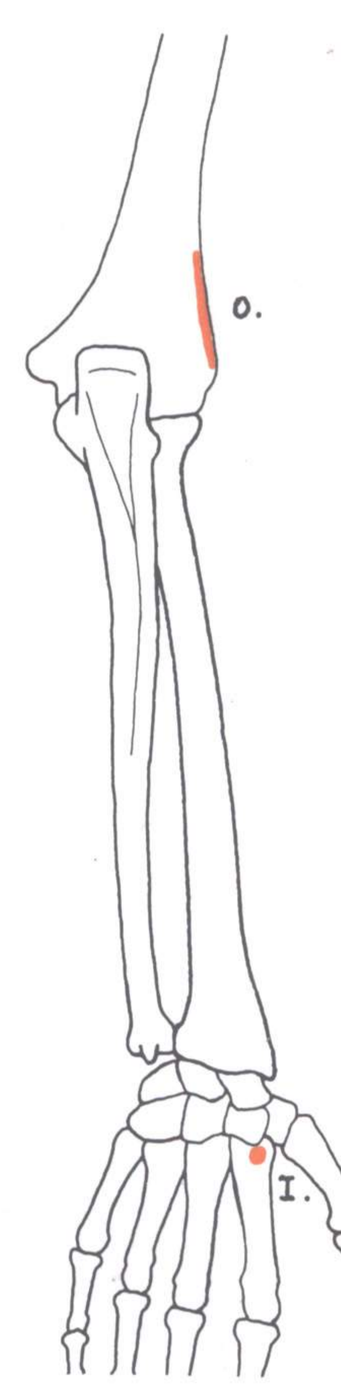
The oblique belly of the extensor carpi radialis longus covers the superior tendon of the extensor carpi radialis brevis.

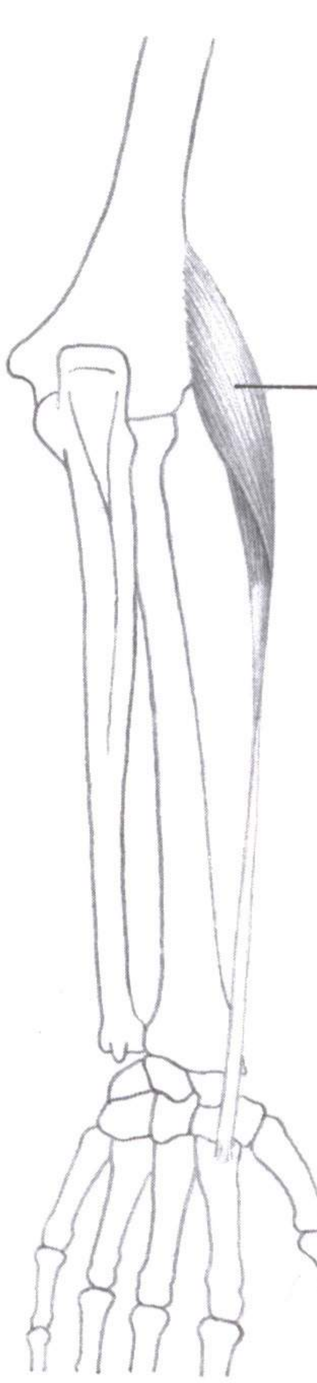


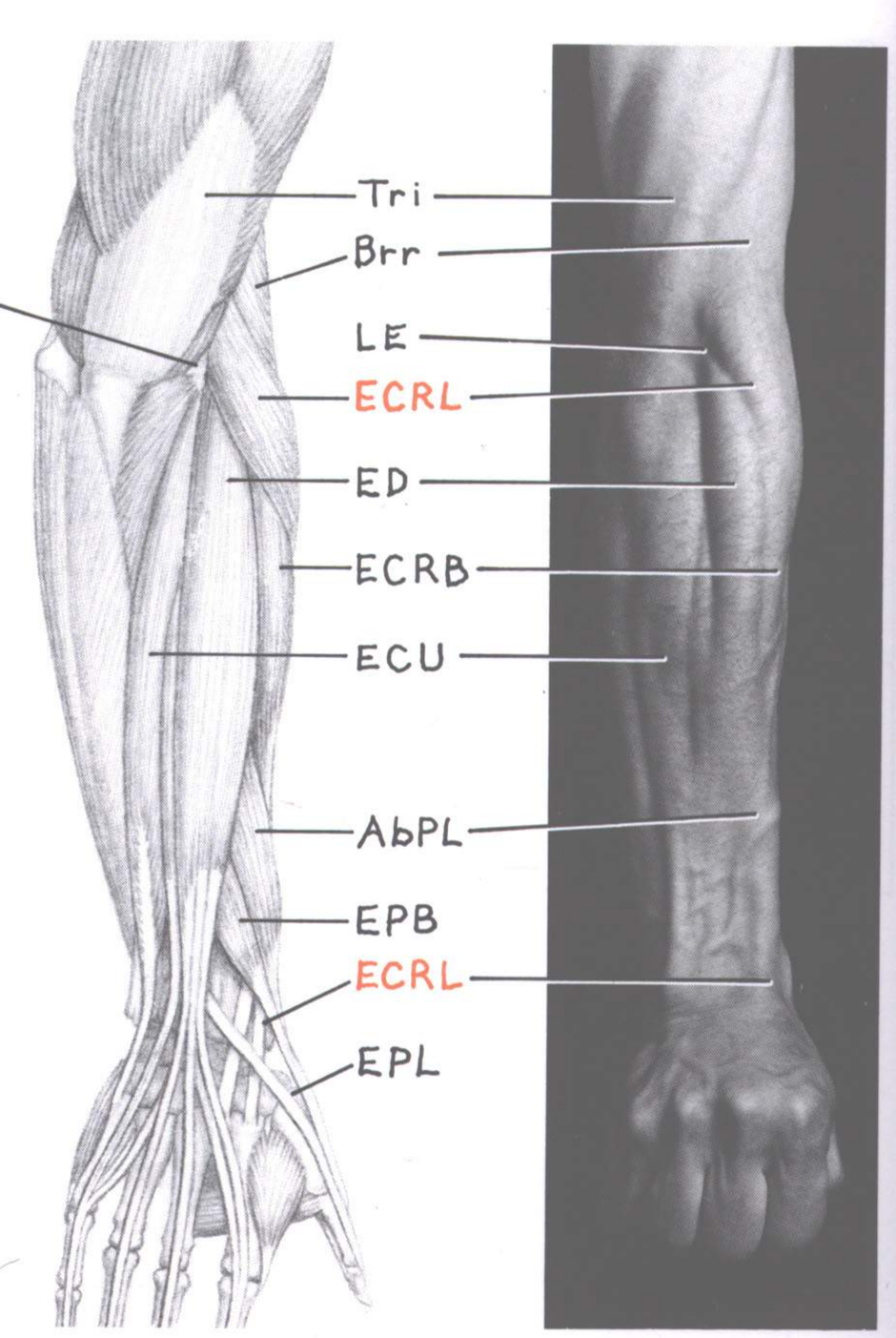




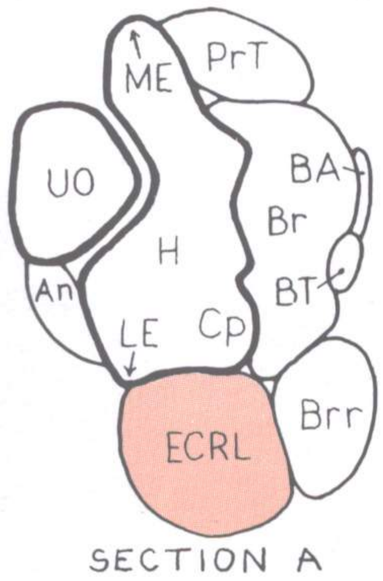








AbPL *Abductor pollicis longus* **Br** *Brachialis* **Brr** *Brachioradialis* **Cp** *Capitulum*
ECRB *Extensor carpi radialis brevis* **ECRL** *Extensor carpi radialis longus* **ECU** *Extensor carpi ulnaris*
ED *Extensor digitorum* **EPB** *Extensor pollicis brevis* **EPL** *Extensor pollicis longus* **H** *Humerus*
LE *Lateral epicondyle* **Ra** *Radius* **Sup** *Supinator* **Tri** *Triceps* **U** *Ulna* **UO** *Ulna—olecranon*



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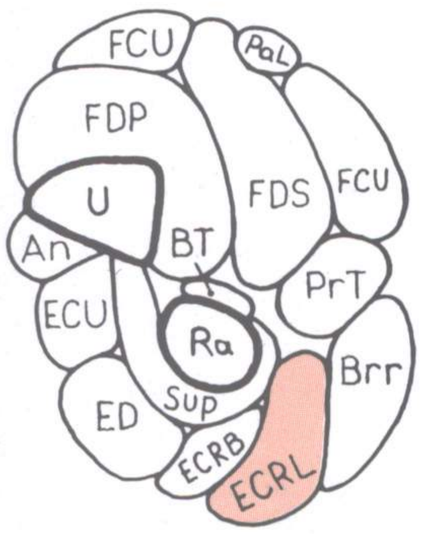

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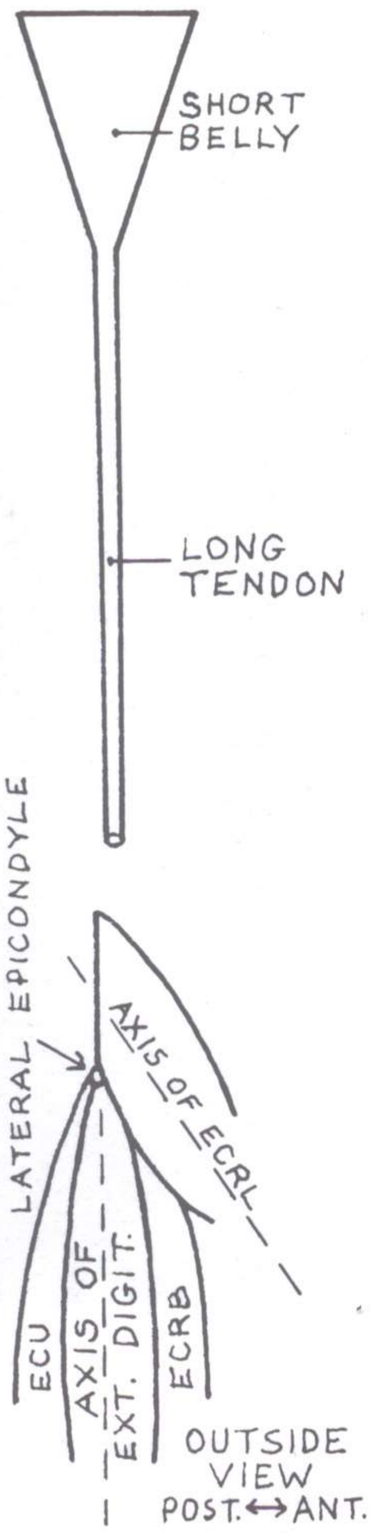


Extensor Carpi Radialis Longus

ORIGIN Lower third of the lateral supracondylar ridge of the humerus, the front of the adjacent lateral intermuscular septum, and minimally from the common extensor tendon originating from the lateral epicondyle of the humerus.

INSERTION Dorsal surface of the metacarpal bone of the index finger, on its radial side.

ACTION Extends and radially deviates the hand at the wrist joint; assists in flexing the elbow joint.

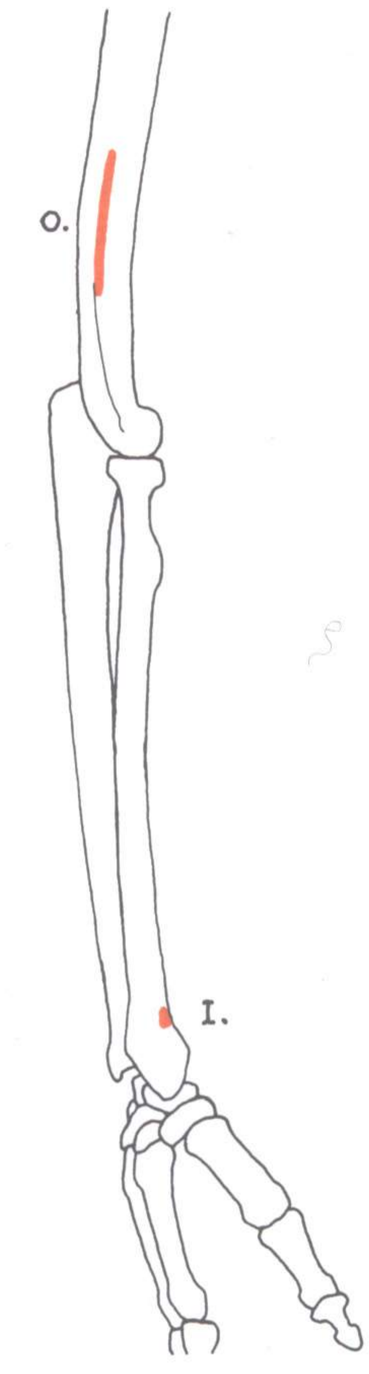
STRUCTURE The extensor carpi radialis longus consists of a *short,* flat, fleshy belly that ends at the upper third of the forearm and a *long,* narrow, flat tendon that continues down the outer edge of the radius, alongside the tendon of the extensor carpi radialis brevis. The tendon then passes down the back surface of the end of the radius in its own bony groove. On the lower half of the forearm, the tendons of these two radial wrist extensors, passing under the abductor pollicis longus and extensor pollicis brevis, may appear as a thin raised ridge when the wrist is extended. After these tendons leave the distal end of the radius, they create a small transitional plane between the back of the wrist and the back of the hand when the wrist is extended.

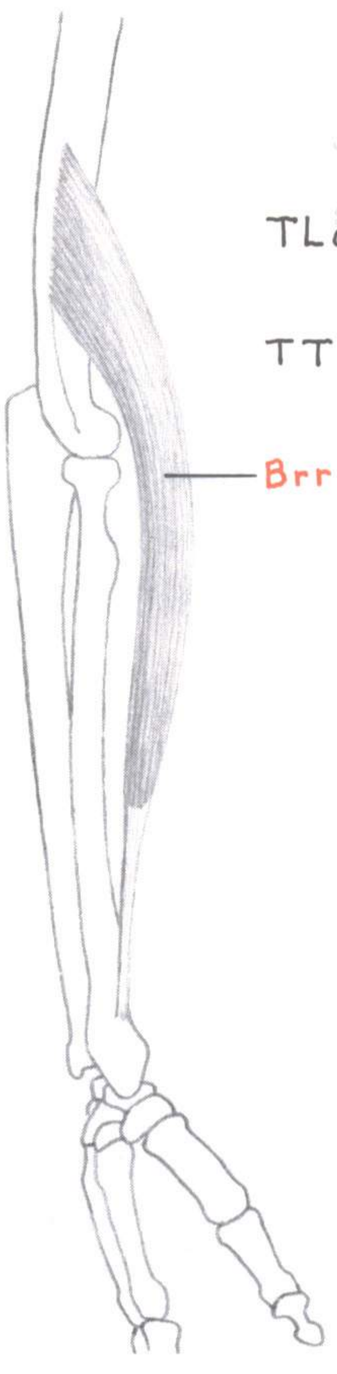
At their superior ends, the extensor carpi radialis longus and brachioradialis begin side by side at their origin, but as they descend, the belly of the extensor carpi radialis longus is soon partially covered by the belly of the brachioradialis. These two muscle bellies typically blend together into a single form when the elbow is extended (there may be a slight separation if the wrist is also extended). When the elbow joint is flexed to 90° with the wrist extended, the belly of the extensor carpi radialis longus is at its shortest and becomes a relatively prominent, short, triangular relief when tensed, quite separate from the brachioradialis. A depression forms where the belly of the extensor carpi radialis longus attaches to its tendon, near the upper end of the forearm. This belly is considerably shorter than the belly of the brachioradialis.

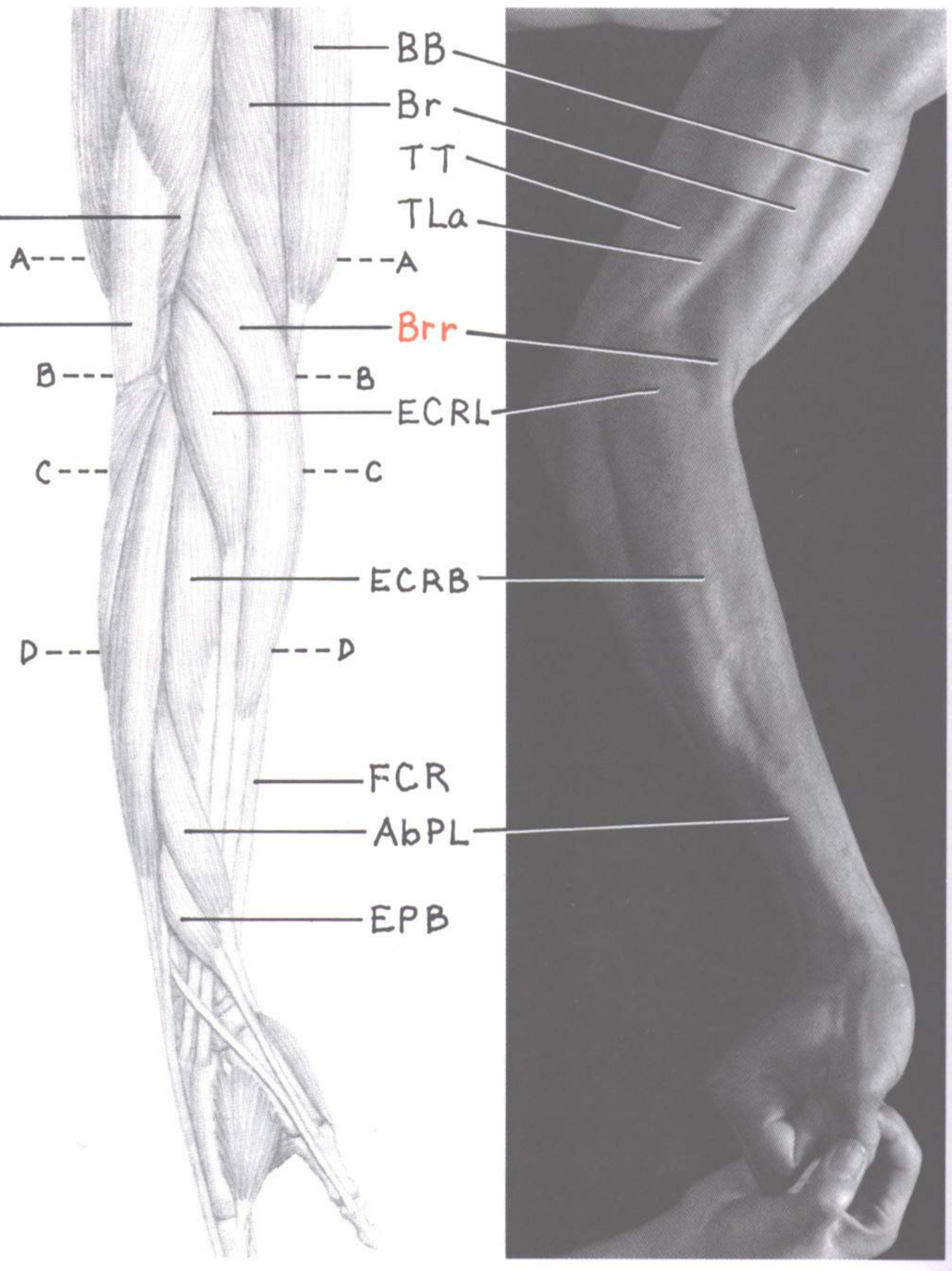
On the outside of the elbow, the lower (posterior) edge of the extensor carpi radialis longus lies oblique to the direction of the forearm extensors, which are directed more or less straight from their origin on the lateral epicondyle of the humerus toward the back of the hand (compare the axis of the extensor digitorum with the lower border of the extensor carpi radialis longus when the elbow is extended).

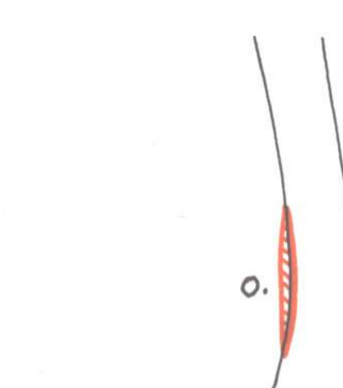
The belly of the extensor carpi radialis longus noticeably bulges more, and is separate from, the epicondyle extensors. In other words, the two *ridge muscles* (brachioradialis and extensor carpi radialis longus—originating from the lateral supracondylar ridge of the humerus) and the three *epicondyle muscles* (extensor carpi radialis brevis, extensor digitorum, and extensor carpi ulnaris—originating from the lateral epicondyle of the humerus) are very different and separate at the elbow. The ridge muscles as a group are oblique (from side to front) to the axis of the forearm, whereas the epicondyle muscles are straight in line with the axis of the forearm, and their upper ends lie recessed from the ridge muscles. Lower down on the forearm, however, all five muscles blend to create the cylindrical (ovoid) form of the forearm.

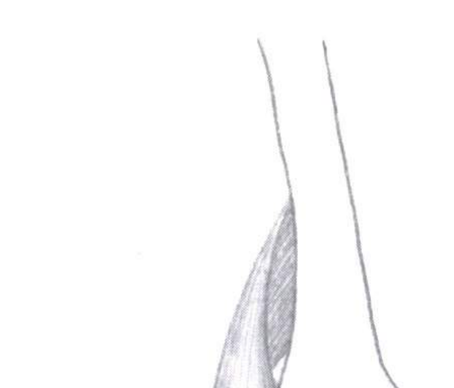
Occasionally, the ridge muscles will blend with the extensor digitorum, separating from the recessed proximal end of the extensor carpi ulnaris.

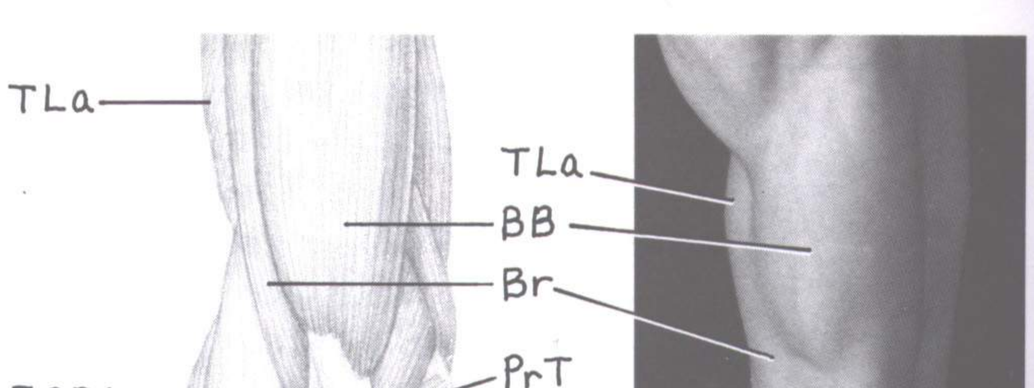




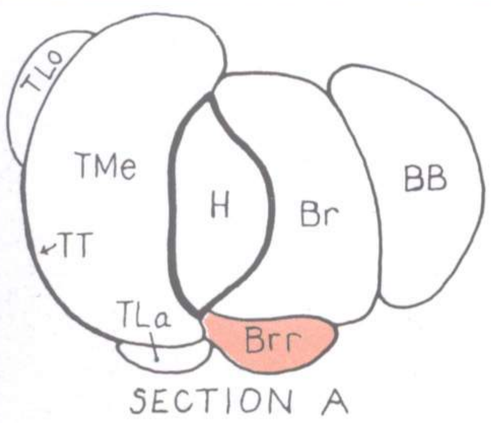








AbPL *Abductor pollicis longus* **BB** *Biceps brachii* **Br** *Brachialis* **Brr** *Brachioradialis*
ECRB *Extensor carpi radialis brevis* **ECRL** *Extensor carpi radialis longus* **EPB** *Extensor pollicis brevis*
FCR *Flexor carpi radialis* **FPL** *Flexor pollicis longus* **H** *Humerus* **PaL** *Palmaris longus*
PrT *Pronator teres* **Ra** *Radius* **TLa** *Triceps—lateral head* **TMe** *Triceps—medial head*
TT *Triceps tendon* **U** *Ulna*



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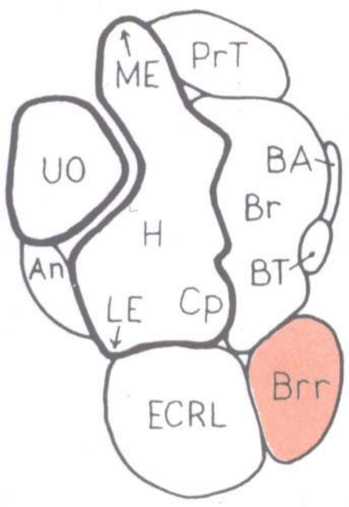

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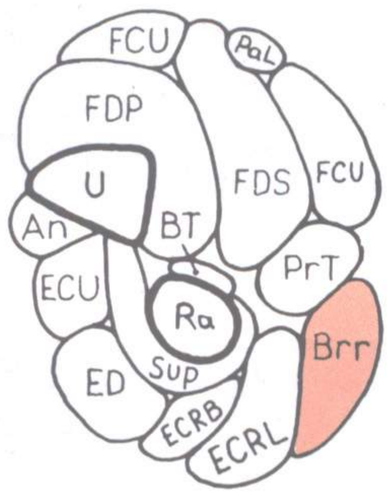

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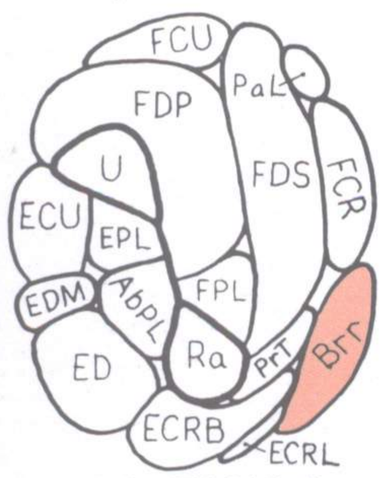


SECTION D

Brachioradialis (Supinator Longus)

ORIGIN Upper two-thirds of the lateral supracondylar ridge of the humerus and the front of the adjacent lateral intermuscular septum.

INSERTION Lateral (thumb) side of the lower end of the radius, just proximal to the styloid process.

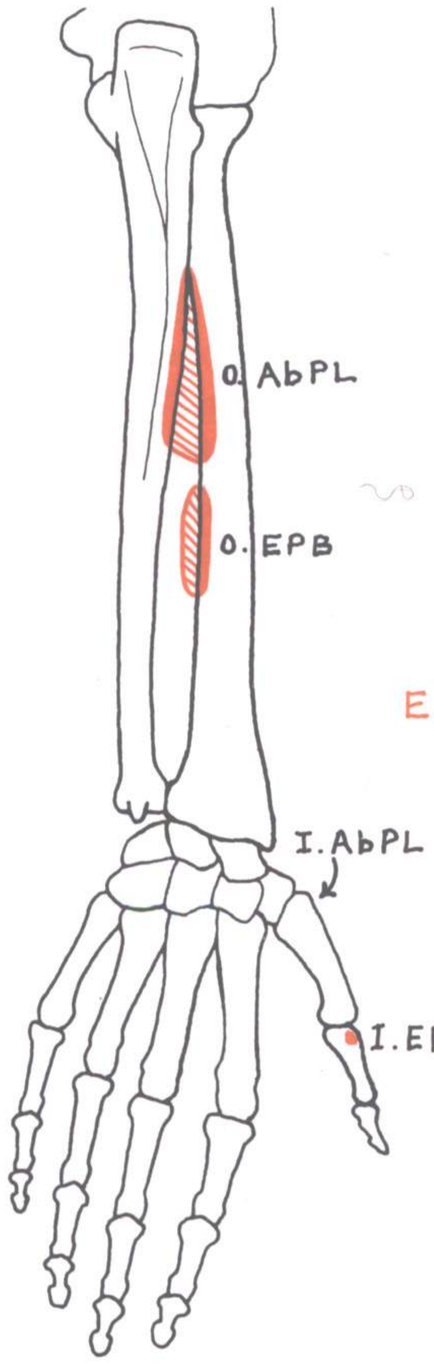
ACTION Flexes the forearm at the elbow joint. It does not pronate or supinate the forearm.

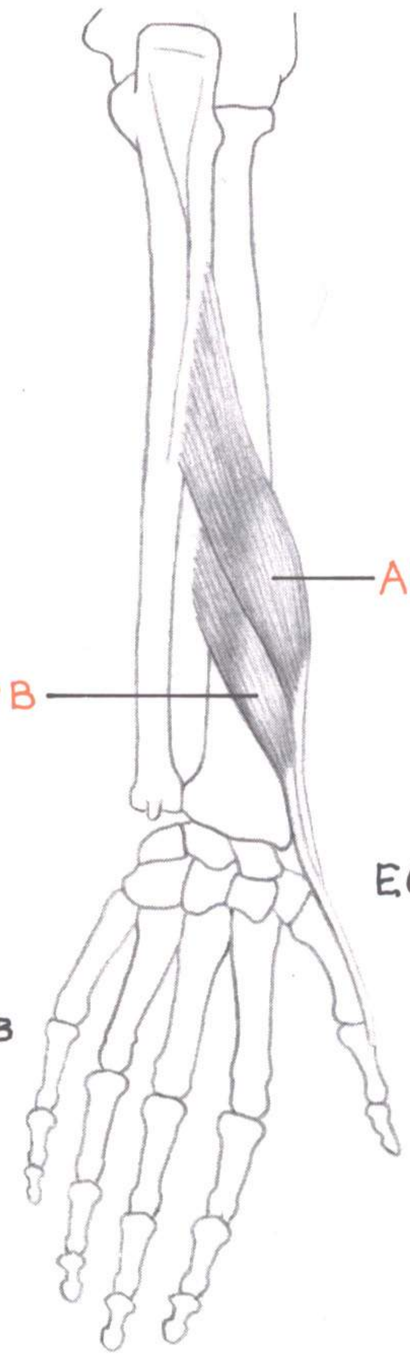
STRUCTURE Originating two-thirds of the way down the humerus between the triceps and brachialis, the belly of the brachioradialis begins wide and flat at its origin, twists toward the front of the arm as it descends (becoming rounder in cross section at the elbow), and widens and flattens again before ending in a flat tendon approximately one-half to two-thirds of the way down the forearm. The superior end of the brachioradialis begins near (approximately two inches from) the insertion of the deltoid. On the forearm, the belly creates a transition between the flexor and extensor muscle groups, partially overlapping the extensor carpi radialis longus on one side and the pronator teres and flexor carpi radialis on the other. The tendon of the brachioradialis lies on the radius and usually is not seen. Unlike most of the long tendons of the forearm, the tendon of the brachioradialis does not cross the wrist joint, but rather stops at the distal end of the radius.

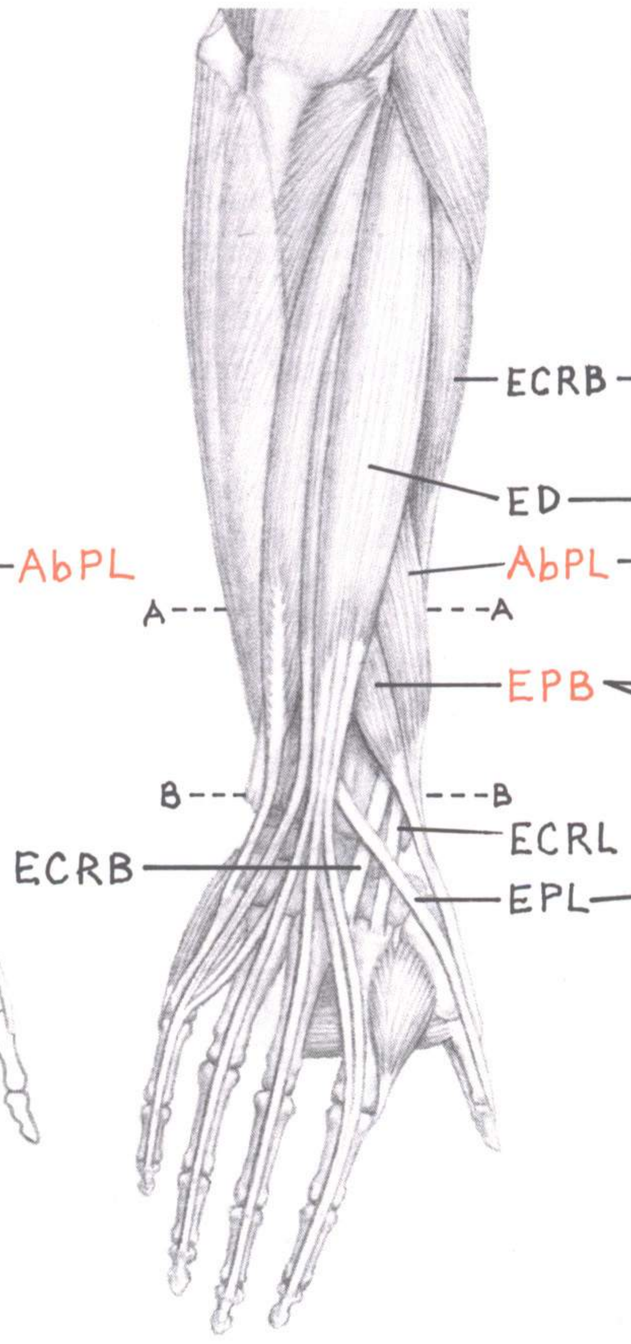
The brachioradialis begins side by side with the extensor carpi radialis longus on the supracondylar ridge, but the former soon partially overlaps the medial edge of the latter as they both descend. Because they both originate from the supracondylar ridge above the lateral epicondyle of the humerus, the muscular form on the outside of the elbow extends higher than the muscular form of the flexor muscles on the inside, which originates lower down on the medial epicondyle. This is especially noticeable when the elbow is flexed.

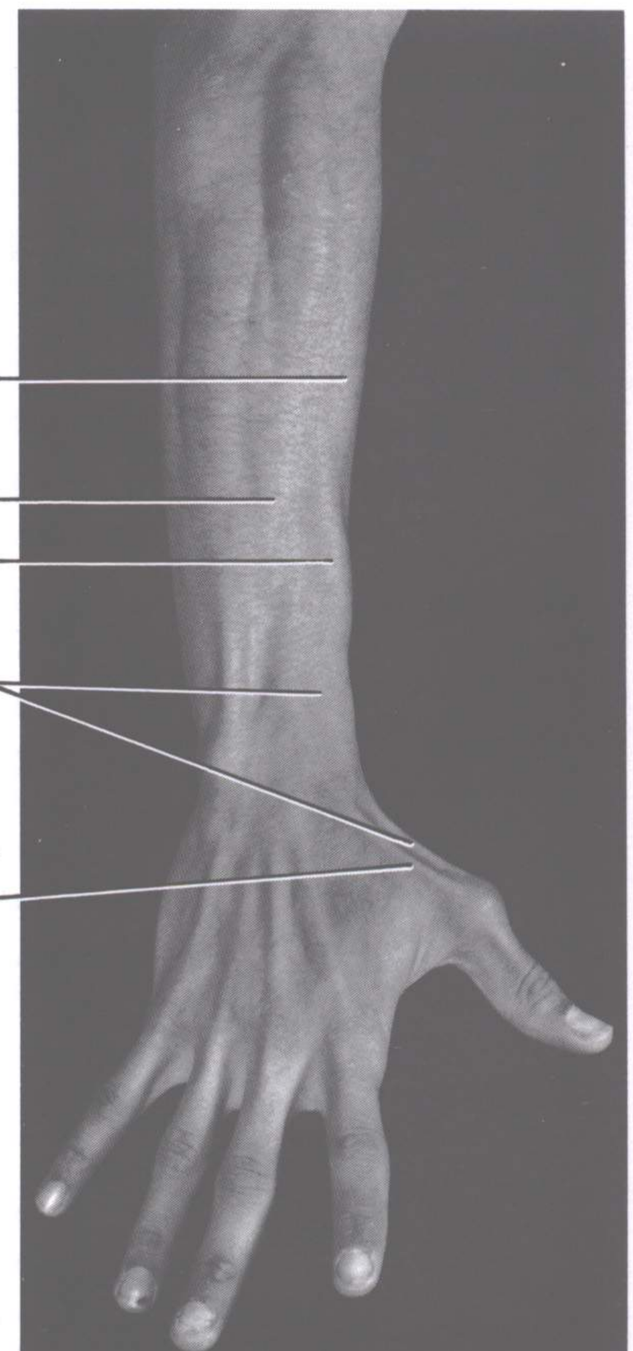
When the brachioradialis is relaxed and the elbow is in any position of flexion, the brachioradialis bends across the middle of its belly at the front of the elbow. The upper fibers inconspicuously contribute to the laterally compressed cylindrical form of the upper arm, while its lower fibers participate in producing the ovoid form of the forearm. If the muscle is then tensed (the forearm flexed against resistance), its belly pops up, creating a thickened raised ridge which passes from the outside of the lower end of the upper arm to the middle of the radial side of the forearm. The form of this ridge, however, remains slightly constricted in front of the elbow, where the bend appears in the relaxed condition. During elbow flexion, two or more skin folds cross the front of the elbow region, passing over the brachioradialis. The distal skin fold coincides with the bend in the belly.

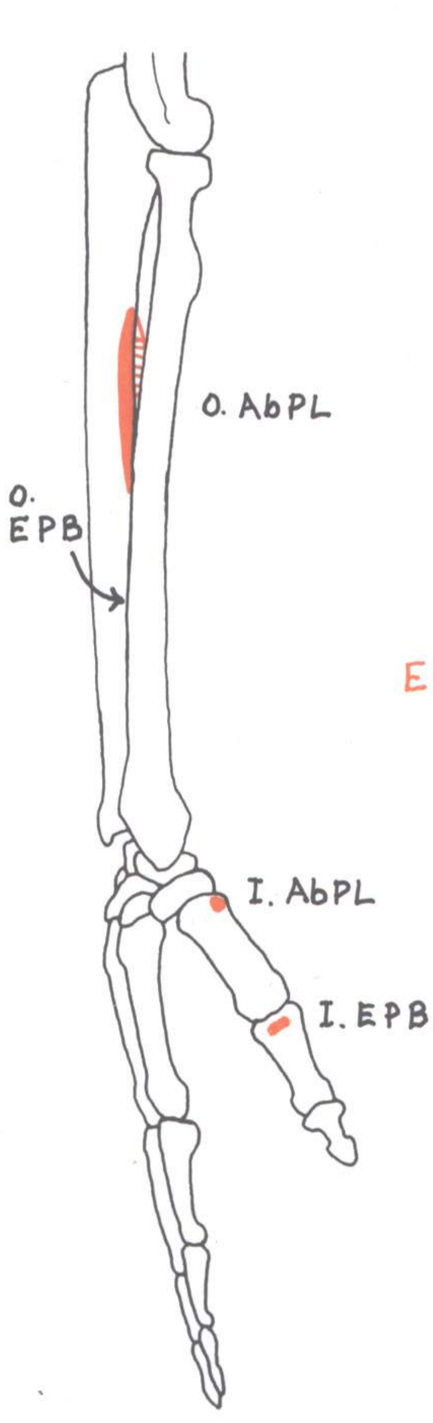
When the elbow is straightened, the brachioradialis and extensor carpi radialis longus—the "ridge muscles"—typically blend together to create a single bulging form on the outside of the elbow.

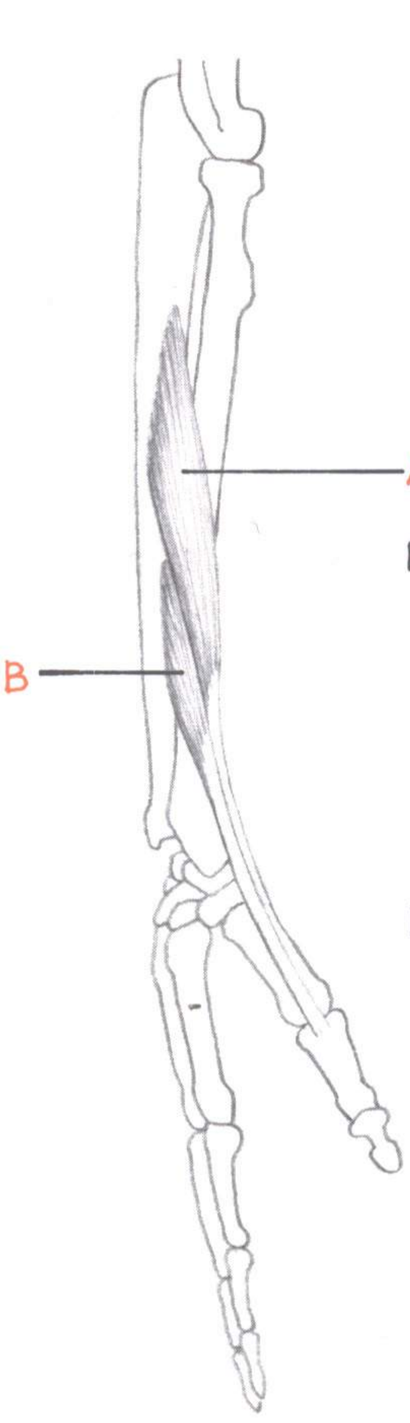


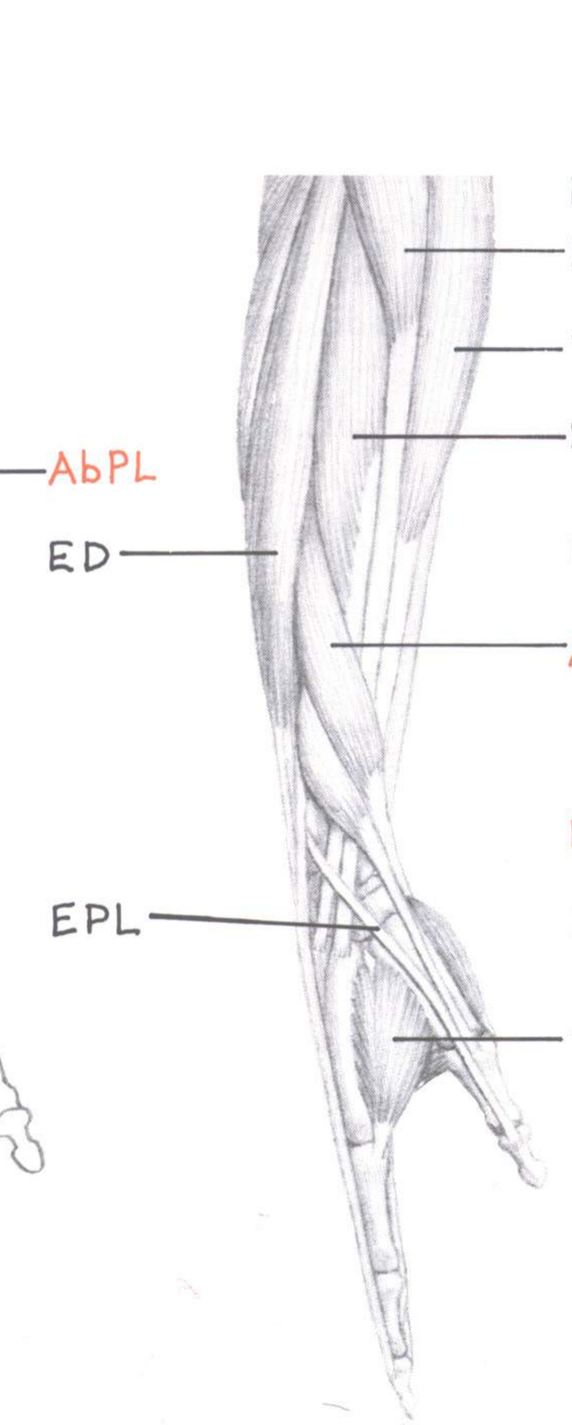


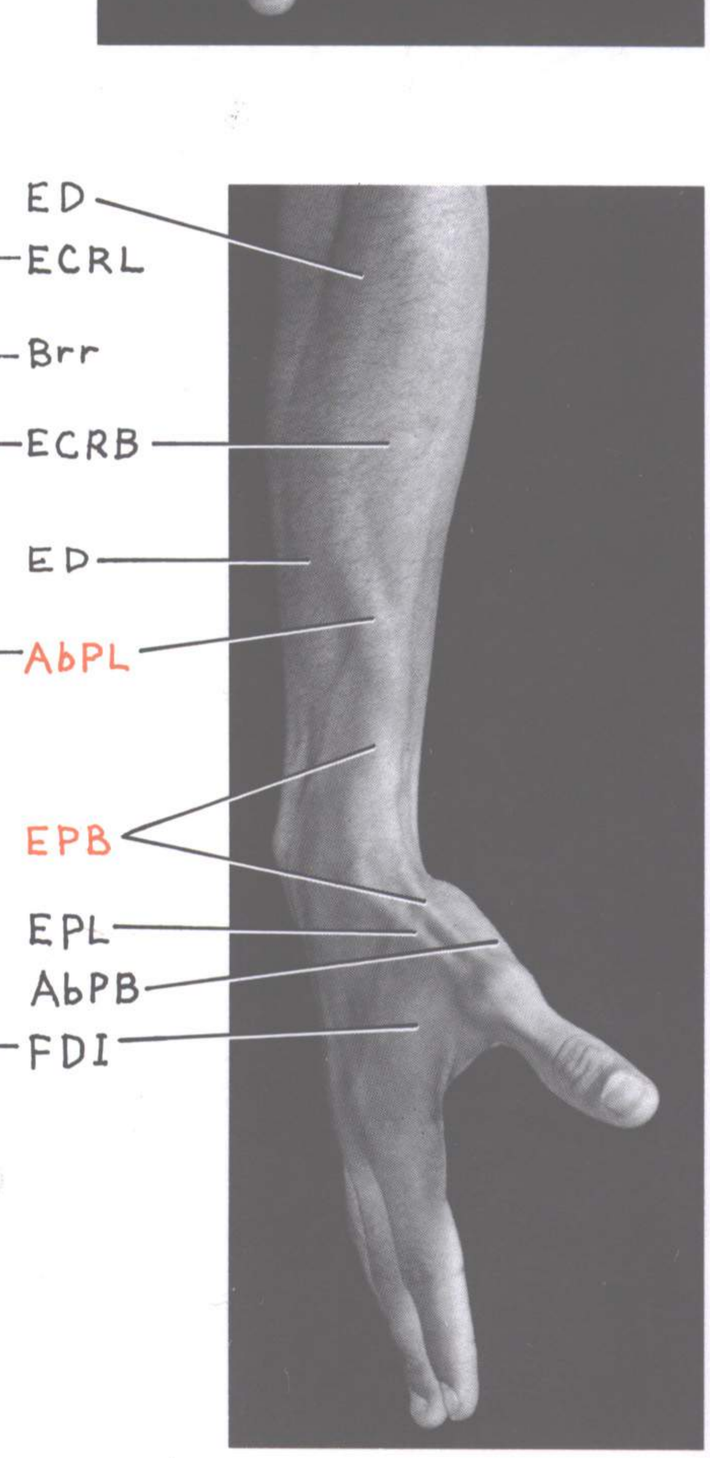




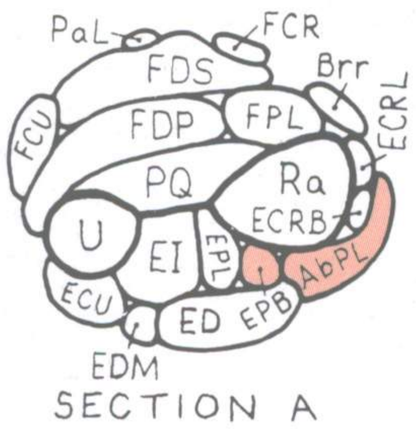








AbPB *Abductor pollicis brevis* **AbPL** *Abductor pollicis longus* **Brr** *Brachioradialis*
ECRB *Extensor carpi radialis brevis* **ECRL** *Extensor carpi radialis longus* **ED** *Extensor digitorum*
EPB *Extensor pollicis brevis* **EPL** *Extensor pollicis longus* **FDI** *First dorsal interosseous*
Ra *Radius* **U** *Ulna*



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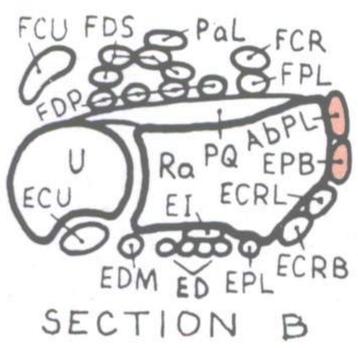

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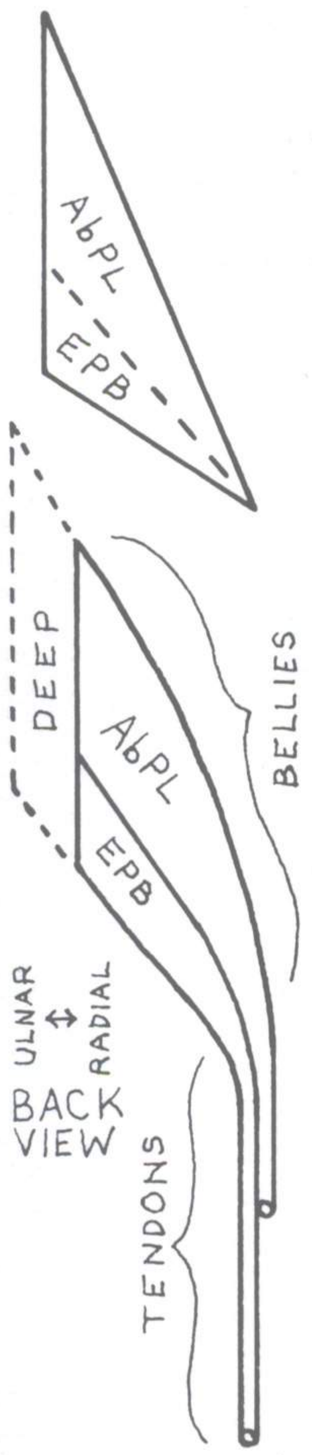


Abductor Pollicis Longus
(Extensor Ossis Metacarpi Pollicis)

ORIGIN Areas on the posterior surfaces of the ulna and radius and the intervening interosseous membrane.

INSERTION Base of the metacarpal bone of the thumb, on its back surface toward its radial side (near the palm).

ACTION Abducts and extends the metacarpal of the thumb. It also radially deviates the hand and assists in flexing the hand at the wrist.

Extensor Pollicis Brevis

ORIGIN Area on the posterior surface of the radius and the adjacent interosseous membrane.

INSERTION Back surface of the base of the proximal phalanx of the thumb.

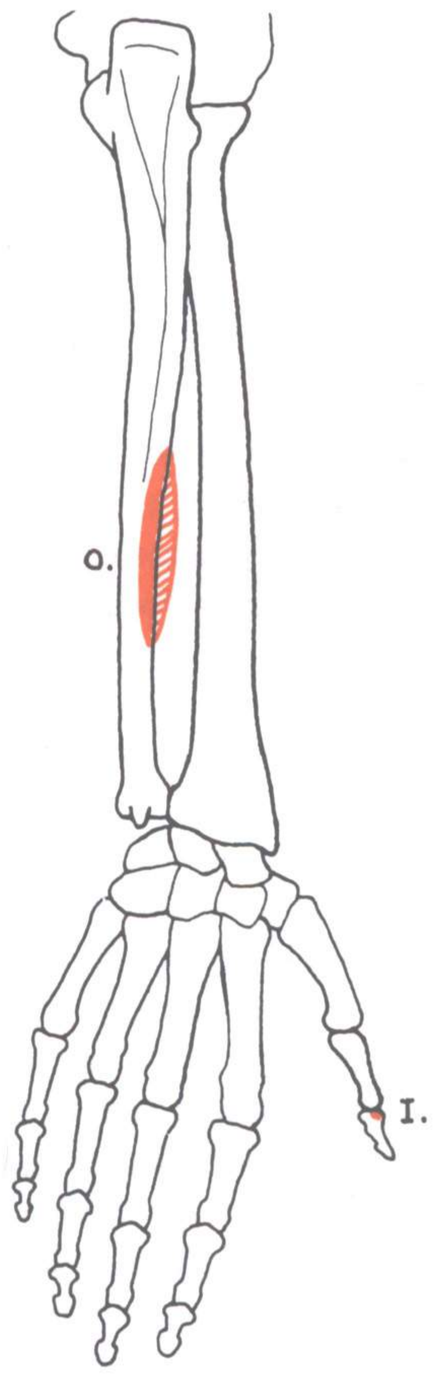
ACTION Extends the proximal phalanx of the thumb, and by continued action extends its metacarpal bone. It also deviates the hand radially.

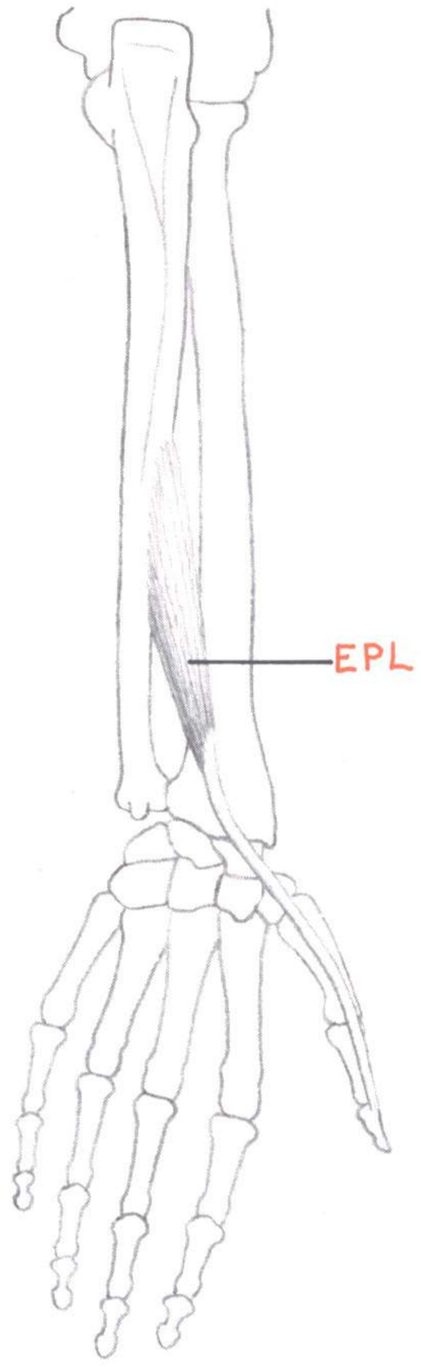
STRUCTURE The **abductor pollicis longus** and **extensor pollicis brevis** combine to create an oblique, narrow, triangular muscular form which wraps around the lower end of the radius. Together they can be considered the **"oblique carpal muscle group."** Their single triangular form can be seen as a small swelling on the lower portion of the lateral side of the radius. The two muscles separate when they are strongly contracted. The oblique carpal muscles produce a small but important convexity three-fourths of the way down the forearm on its outer (radial) profile.

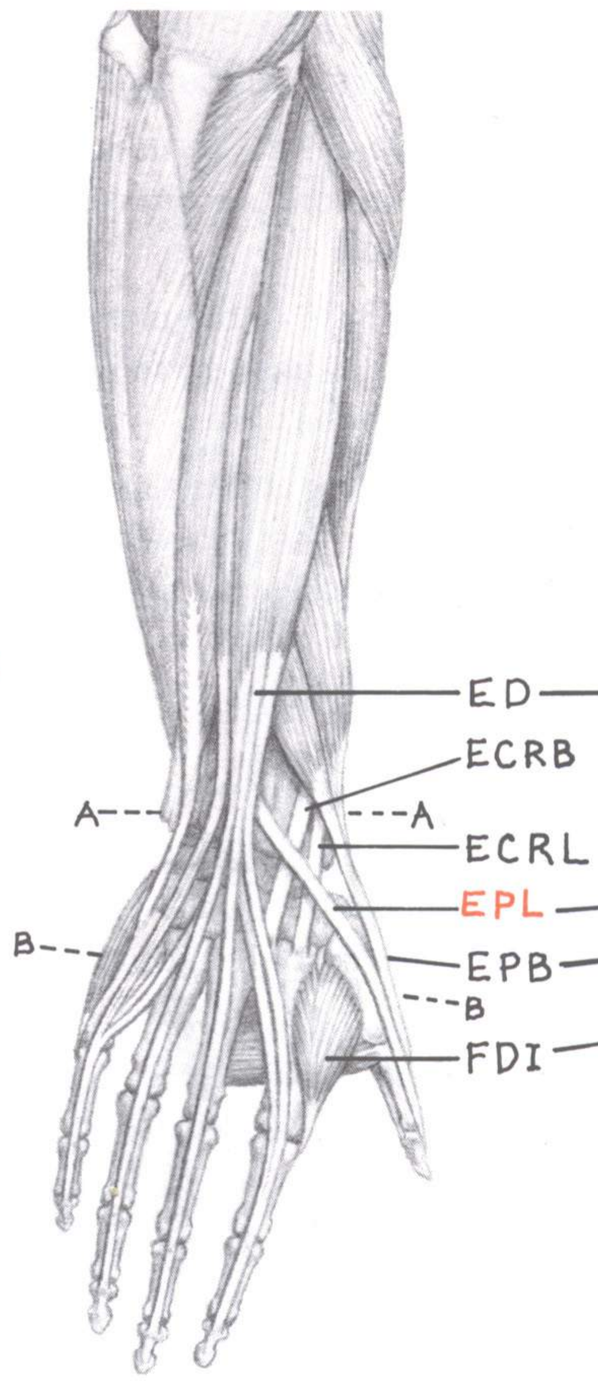
Arising deep in the back of the forearm, the two flattened muscle bellies emerge from under the extensor digitorum and then cross over the tendons of the extensor carpi radialis brevis and longus in their oblique descent down the lower portion of the forearm. They become tendinous on the outer edge of the radius and pass downward together through a shallow bony groove on the lower end of the outside of the radius. The tendons usually *appear* to end at the base of the metacarpal of the thumb, forming the palmar tendon of the anatomical snuffbox at the wrist (see Extensor Pollicis Longus). As they cross the wrist joint, the tendon of the extensor pollicis brevis lies dorsal to, and usually adjacent to, the tendon of the abductor pollicis longus.

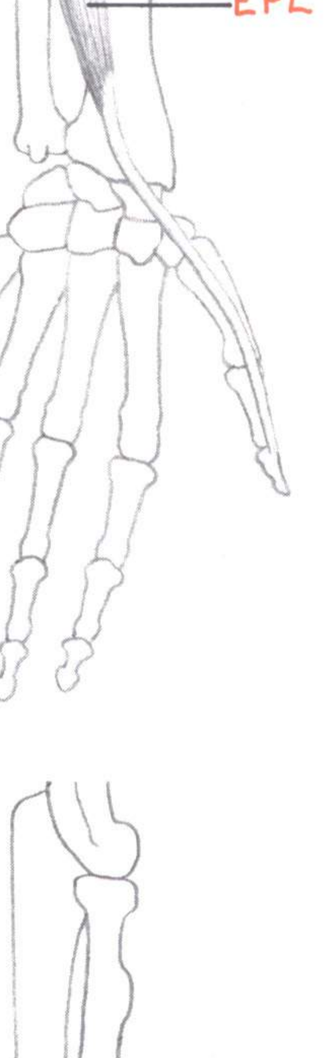
The **tendon of the abductor pollicis longus** inserts into the base of the metacarpal of the thumb, frequently sending tendinous slips to the trapezium bone of the carpus and the *surface* of the abductor pollicis brevis muscle at its origin. This tendon is thick and strong and actually consists of up to seven or eight combined tendons. Several of these are often seen on the surface, especially when the thumb is moved forward and back at the carpometacarpal joint.

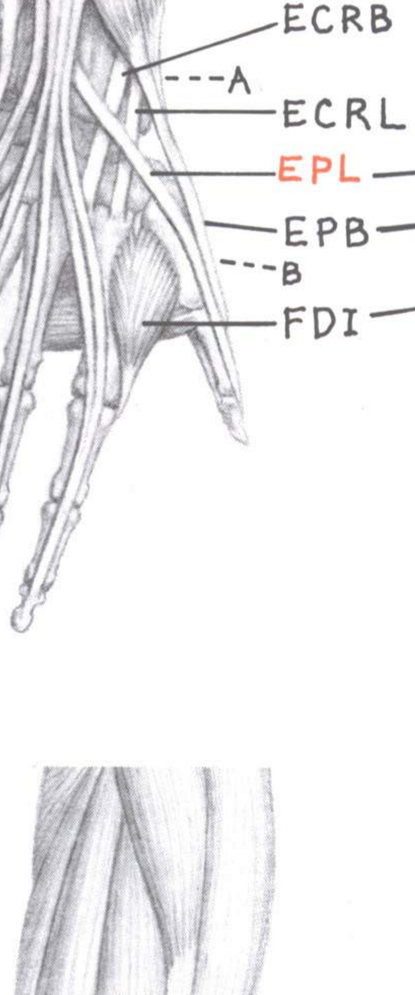
The very slender **tendon of the extensor pollicis brevis** passes down the back of the metacarpal of the thumb. It may be inconspicuous or quite distinct, first passing down the middle of the snuffbox and then down the back surface of the metacarpal of the thumb. When the extended thumb is advanced forward away from the palm (along a plane perpendicular to the plane of the palm), the tendons of extensor pollicis brevis and longus converge distally at the metacarpophalangeal joint of the thumb.

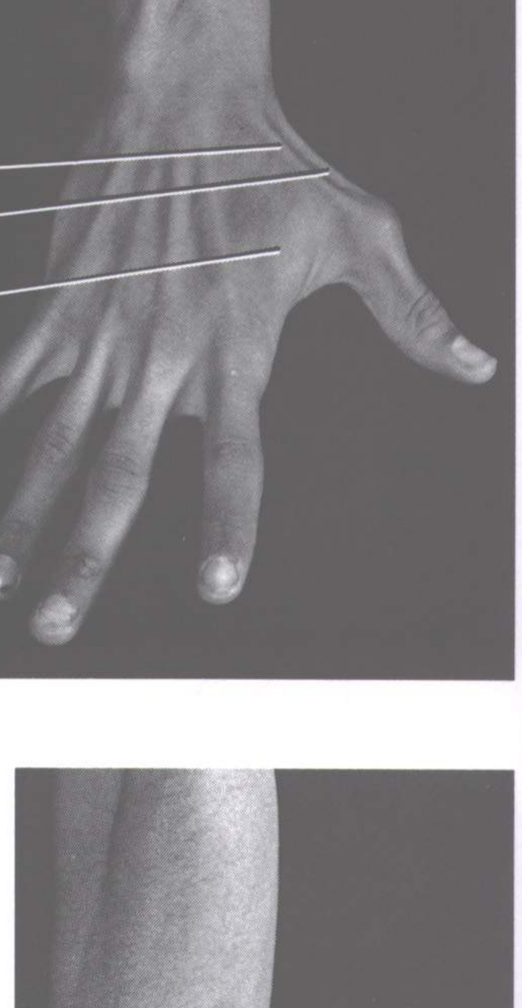




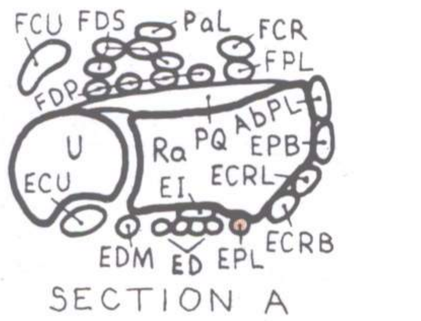








AbPB *Abductor pollicis brevis* **AbPL** *Abductor pollicis longus* **ECRB** *Extensor carpi radialis brevis*
ECRL *Extensor carpi radialis longus* **ED** *Extensor digitorum* **EPB** *Extensor pollicis brevis*
EPL *Extensor pollicis longus* **FDI** *First dorsal interosseous* **M** *Metacarpal* **Ra** *Radius* **U** *Ulna*



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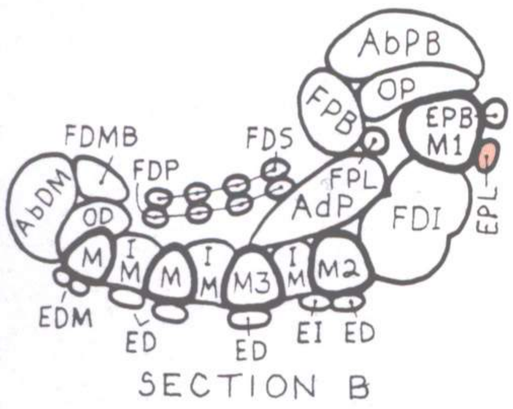

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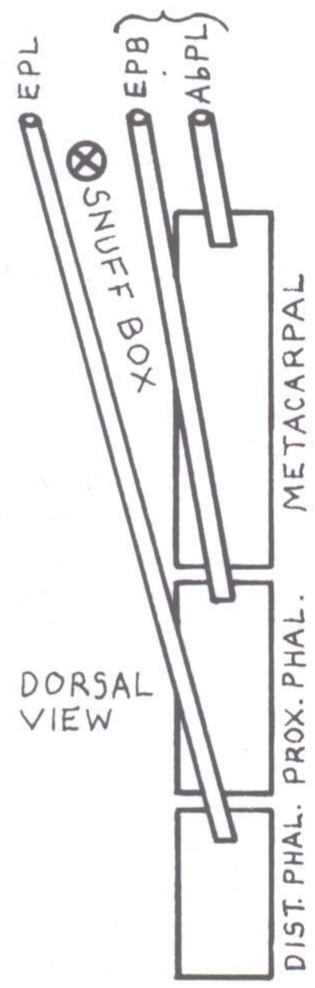


BONES OF THE THUMB

Extensor Pollicis Longus

ORIGIN Middle third of the lateral portion of the posterior surface of the ulna and the adjacent area on the interosseous membrane.

INSERTION Back surface of the base of the distal phalanx of the thumb.

ACTION Extends the distal phalanx of the thumb, and by continued action, extends its proximal phalanx and metacarpal bone. It also adducts the thumb at the carpometacarpal joint, even when the thumb is flexing at the metacarpophalangeal and interphalangeal joints. It assists in extending the hand at the wrists.

STRUCTURE Beginning deep in the forearm, only the tendon of the extensor pollicis longus becomes visible after it leaves its oblique bony groove on the middle of the back of the distal end of the radius. At this point, it turns sharply toward the thumb, crosses over the tendons of the extensor carpi radialis brevis and longus, and descends along the back of the thumb—not directly on the midline, but slightly toward its ulnar (index finger) side. The tendon can usually be seen as far down as the interphalangeal joint. This tendon is very prominent when the thumb is extended and disappears when the thumb is flexed at the carpometacarpal joint. If the thumb is extended and then adducted toward the index finger, the visible tendon of the extensor pollicis longus bends (changes direction) at the metacarpophalangeal joint of the thumb.

Tendons to the Thumb

The thumb has three bones: a metacarpal, proximal phalanx, and distal phalanx. The base of each bone receives a tendon from a muscle. In other words, there are three bones and three tendons, one tendon per bone. The base of the metacarpal receives the tendon of the abductor pollicis longus (often a complex multiple tendon), the base of the proximal phalanx receives the tendon of the extensor pollicis brevis, and the base of the distal phalanx receives the tendon of the extensor pollicis longus. The tendons of the abductor pollicis longus and extensor pollicis brevis usually combine together visually, especially at the anatomical snuffbox (see below).

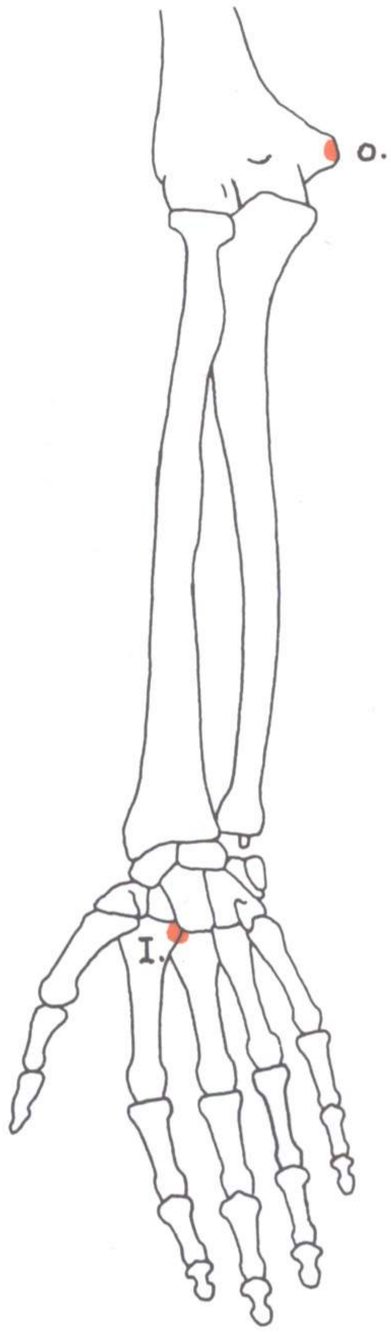
The three tendons to the thumb are part of the extrinsic muscle group of the hand. These muscles originate in the forearm and insert into the hand. Only their tendons are present in the hand (on the thumb).

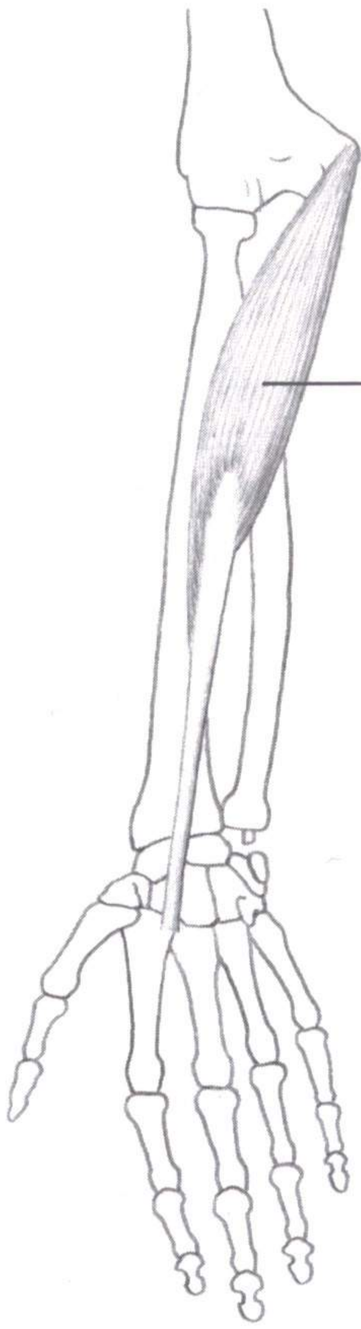
The Anatomical Snuffbox

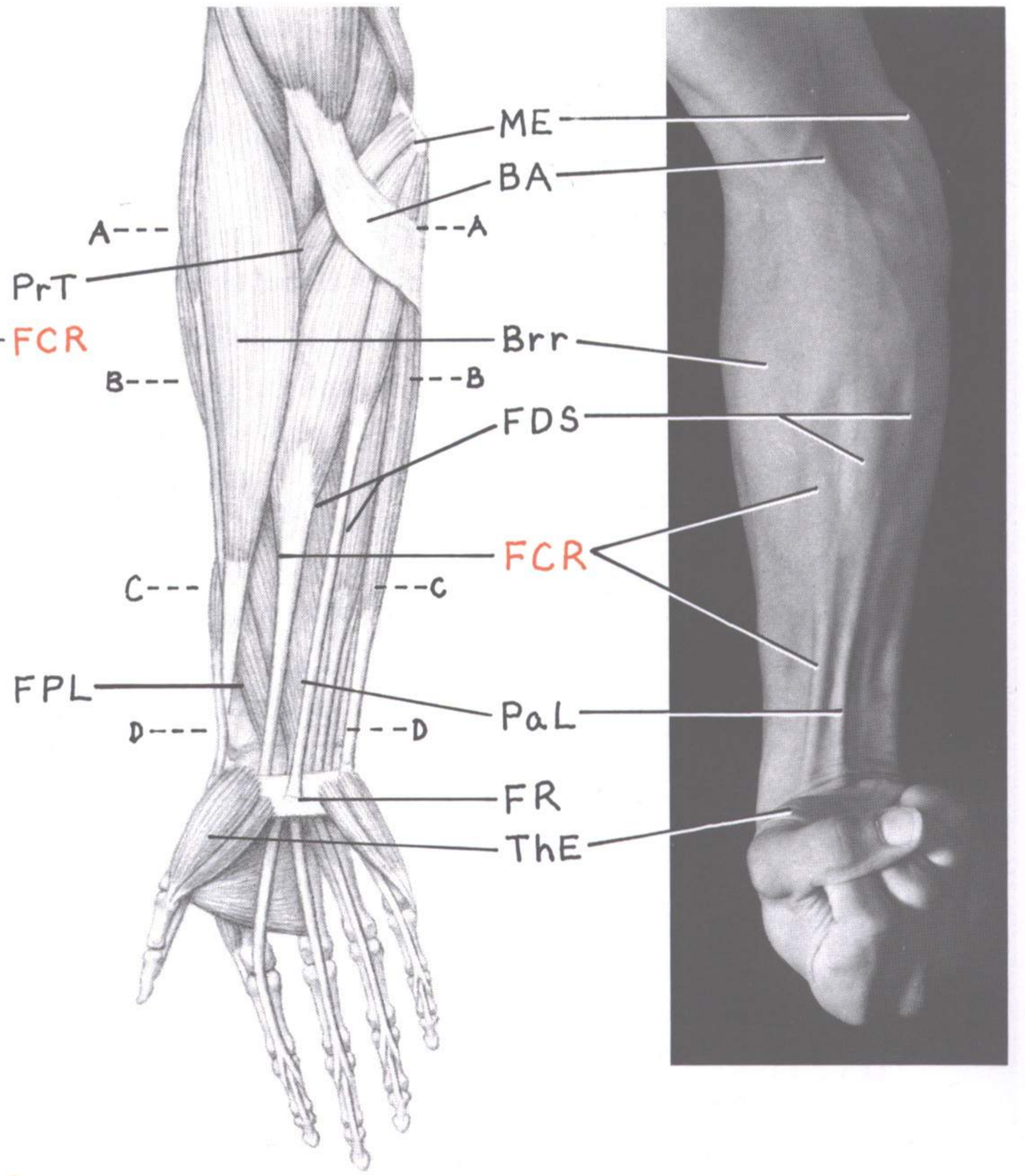
The **anatomical snuffbox** is the square, hollow depression located on the radial side of the wrist. It is bordered by the tendon of the extensor pollicis longus on the dorsal (posterior) corner of the wrist, the combined tendons of the extensor pollicis brevis and abductor pollicis longus on the palmar (ventral or anterior) corner of the wrist, the distal end of the radius proximally, and the base of the metacarpal of the thumb distally. The lateral carpal bones lie at the floor of the snuffbox.

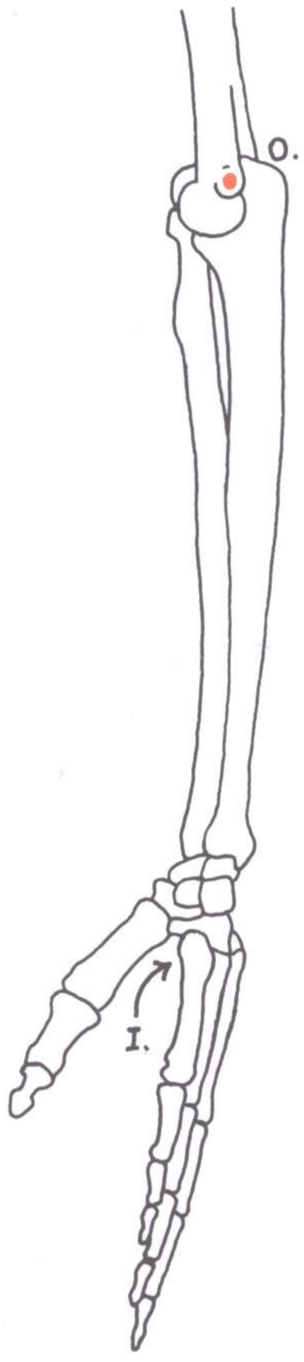
The snuffbox appears when the thumb is extended with the tendons prominent. If the thumb is then abducted away from the palm (along a plane perpendicular to the plane of the palm), the tendons bordering the snuffbox converge distally.

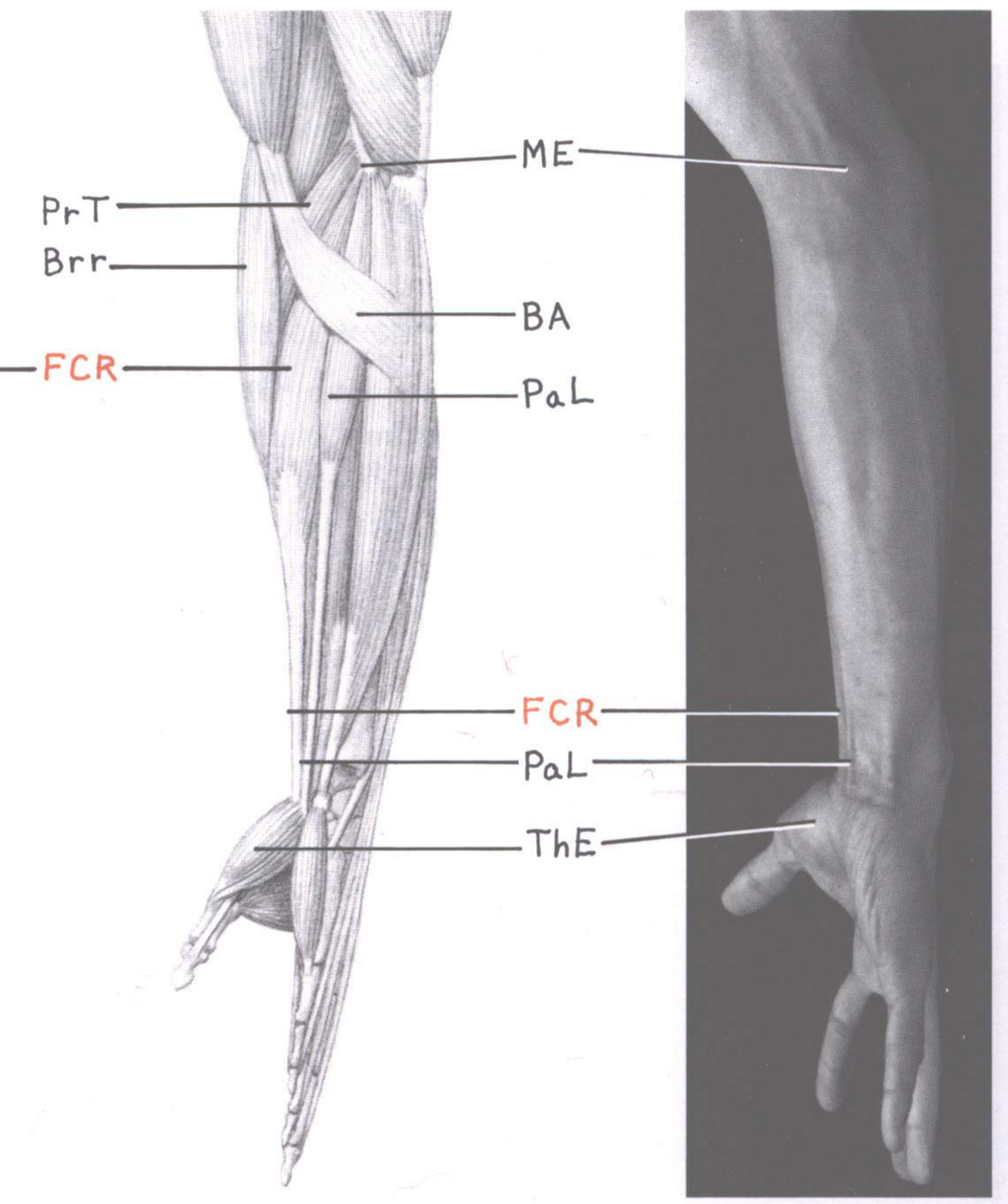
The tendon of the extensor pollicis brevis may either combine visually with the tendon of the abductor pollicis longus, lie inconspicuously on the outside of the wrist, or become visible between the tendons of the extensor pollicis longus and abductor pollicis longus as it passes down the center of the snuffbox and then down the dorsal surface of the metacarpal of the thumb.



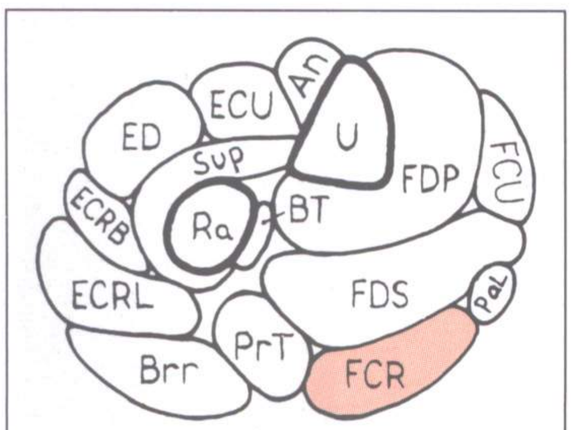


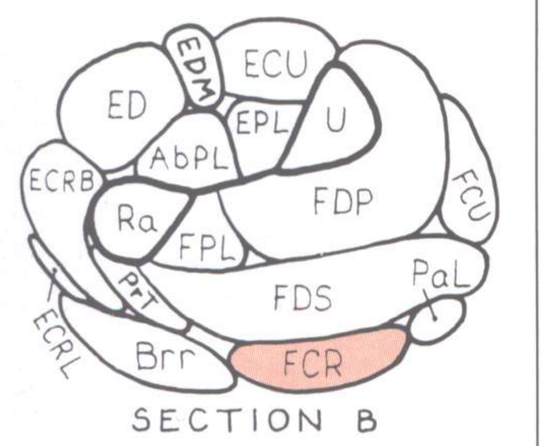


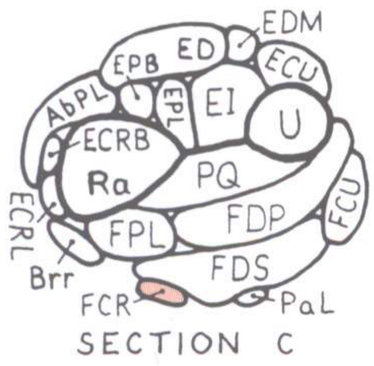


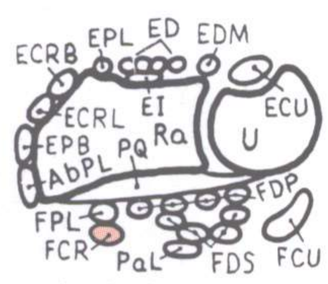


BA *Bicipital aponeurosis* **Brr** *Brachioradialis* **FCR** *Flexor carpi radialis*
FDS *Flexor digitorum superficialis* **FPL** *Flexor pollicis longus* **FR** *Flexor retinaculum*
ME *Medial epicondyle* **PaL** *Palmaris longus* **PrT** *Pronator teres* **Ra** *Radius* **ThE** *Thenar eminence*
U *Ulna*









Flexor Carpi Radialis

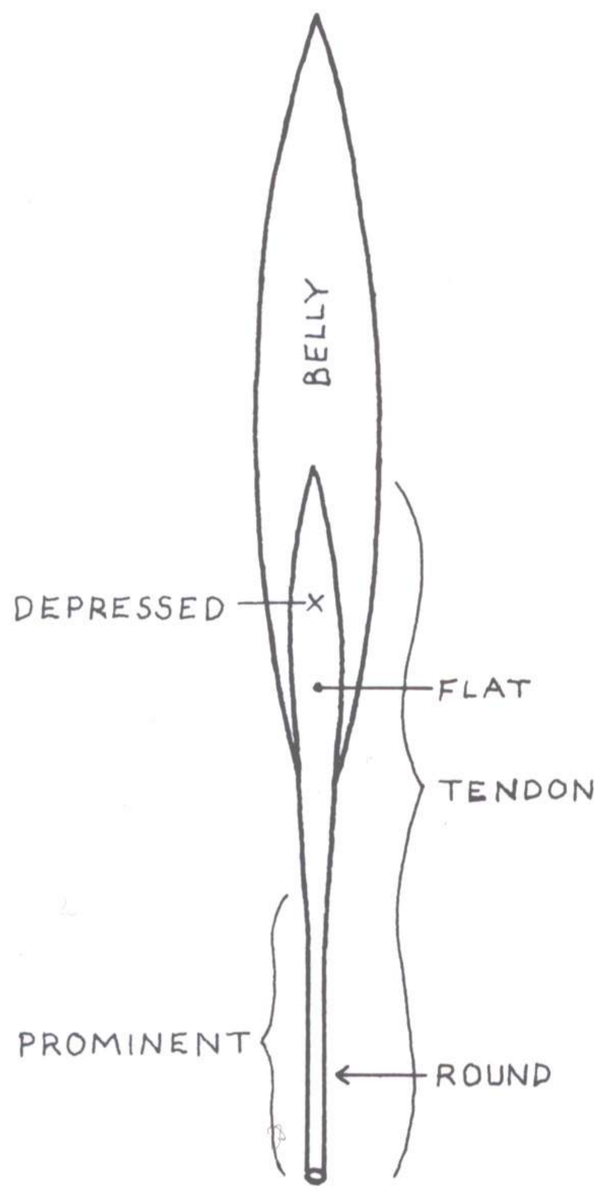
ORIGIN Medial epicondyle of the humerus (by the common flexor tendon).

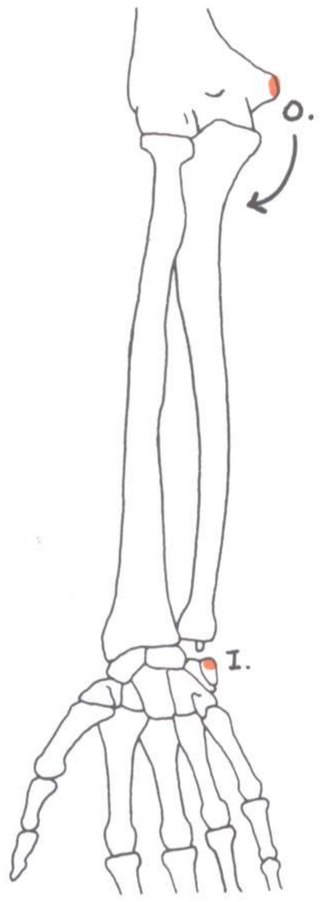
INSERTION Bases of the metacarpal bones of the index and middle fingers, deep in the palm.

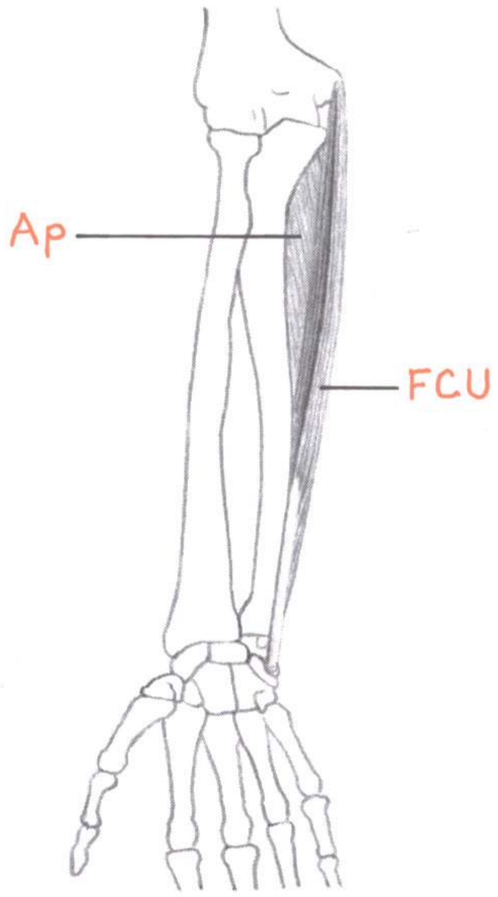
ACTION Flexes and radially deviates the hand at the wrist joint.

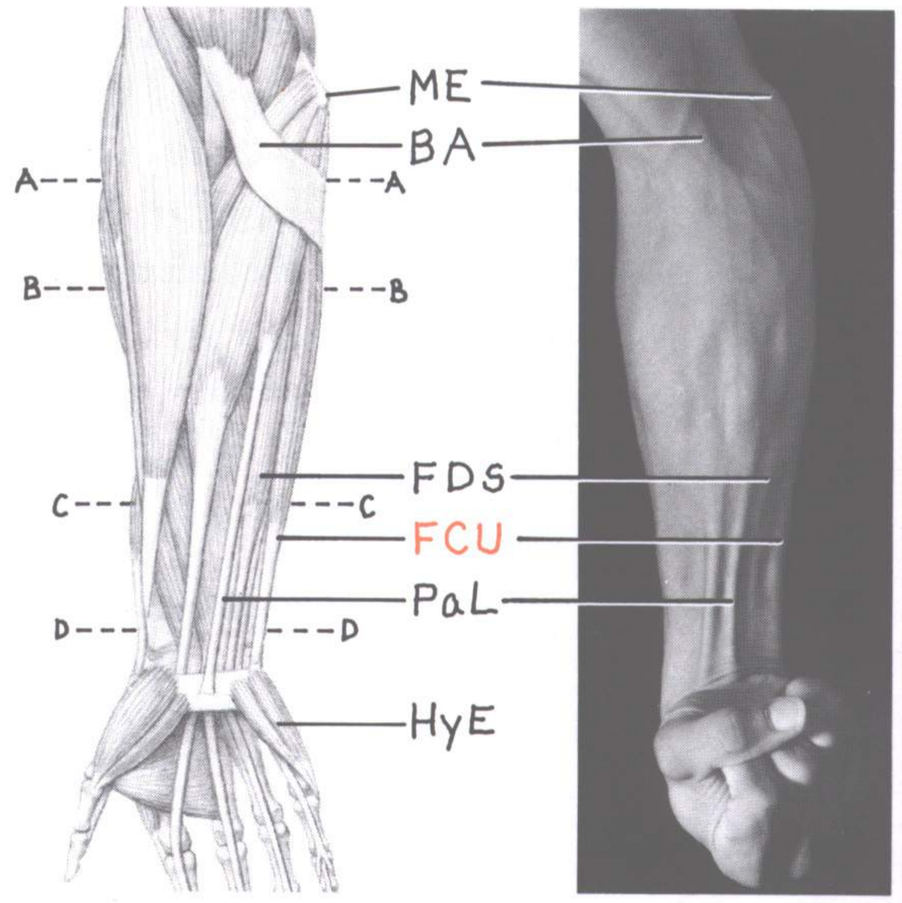
STRUCTURE The fleshy belly of the flexor carpi radialis, located on the *upper half* of the forearm, is slightly flattened distally. Its tendon, beginning *one-third* of the way down the forearm, is flat, wide, and pointed proximally and rounded distally. The muscle fibers of the belly split and pass down each side of the tendon for a short distance. Because of this arrangement, when the muscle is tensed, the wide proximal end of the tendon usually becomes slightly depressed between the bulging V-shaped distal end of the belly. The muscle fibers on the radial side of the tendon then blend visually with the form of the brachioradialis.

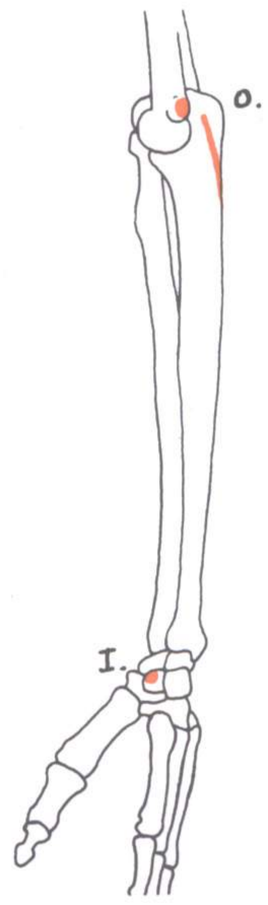
Just proximal to the wrist, the cordlike tendon of the flexor carpi radialis is very prominent, especially when the wrist is flexed and radially deviated. It lies just off the midline, toward the radial side of the forearm. This tendon is thicker than the tendon of the palmaris longus, is directed toward the index finger (when the hand is straight), and passes out of view at the base of the hand. In the anatomical position (supinated forearm), the entire flexor carpi radialis lies oblique on the forearm, as it passed from its origin to its insertion.

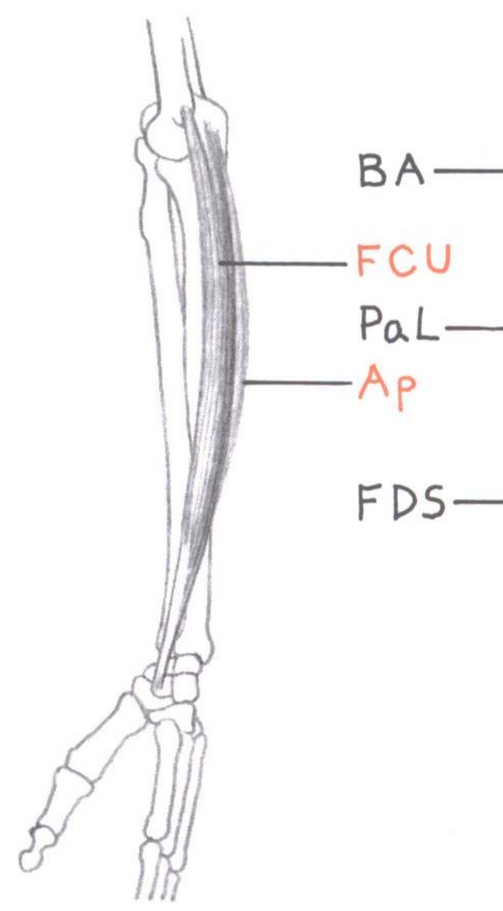


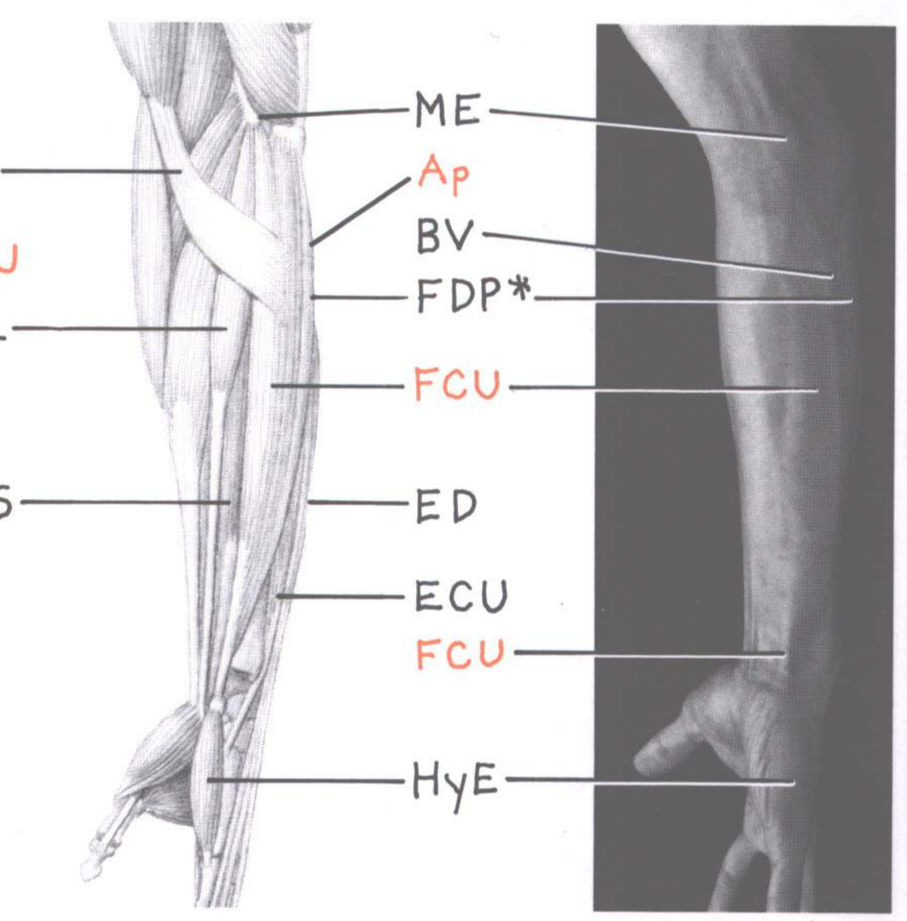


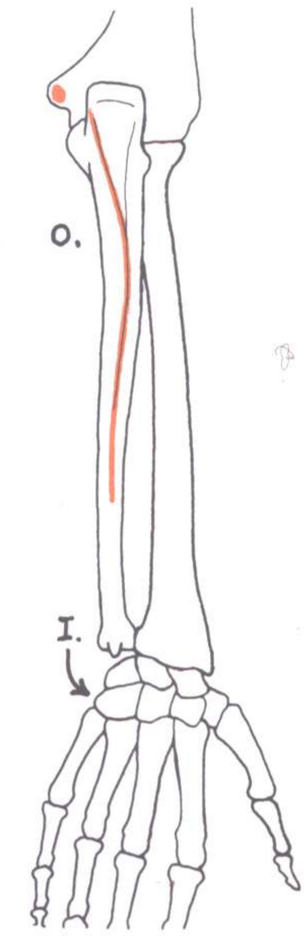


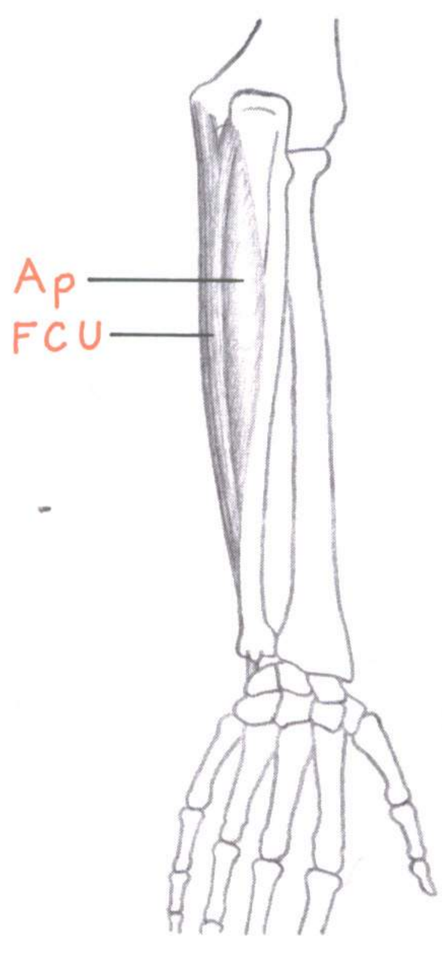


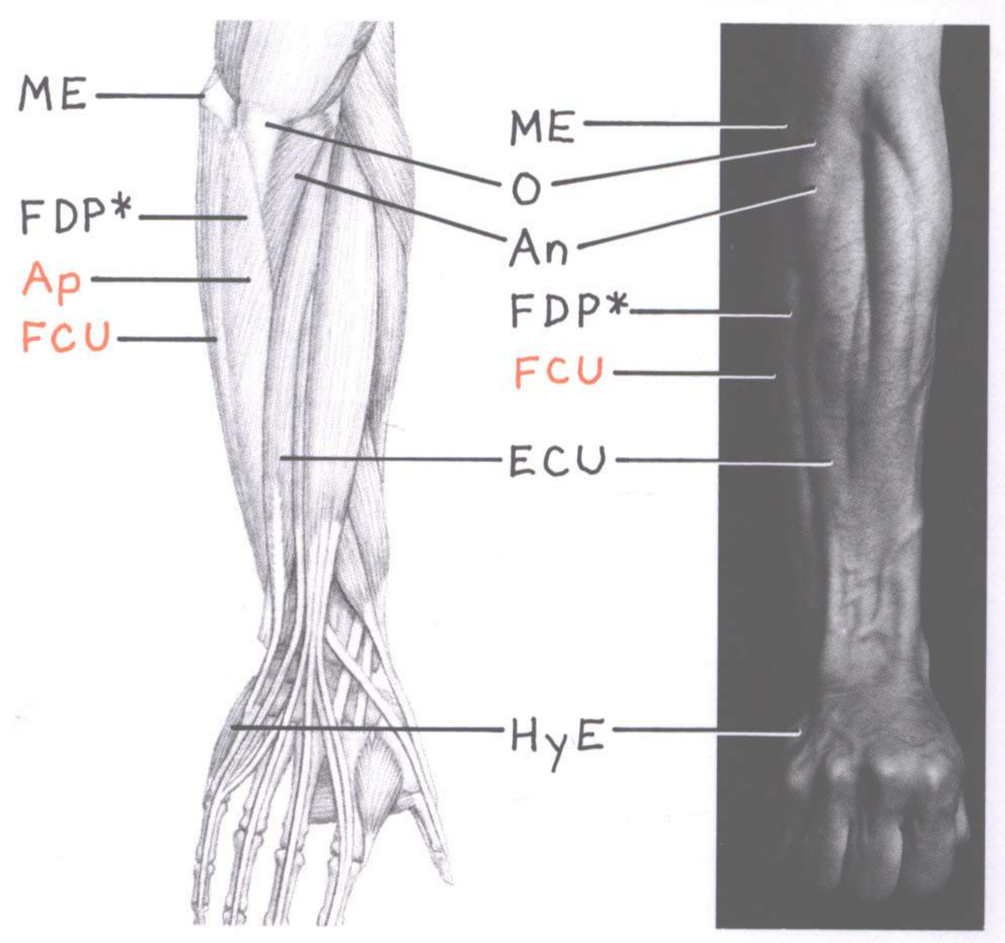




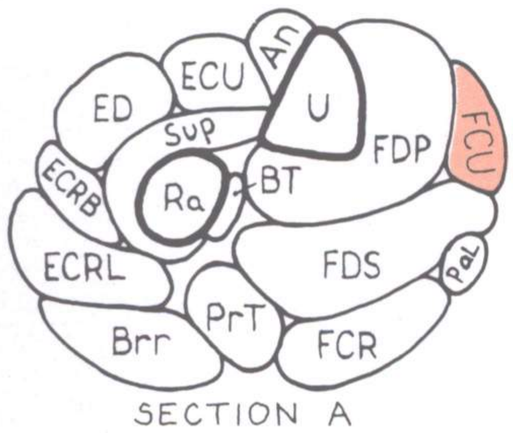








An *Anconeus* **Ap** *Aponeurosis* **BA** *Bicipital aponeurosis* **BV** *Basilic vein* **ECU** *Extensor carpi ulnaris* **ED** *Extensor digitorum* **FCU** *Flexor carpi ulnaris* **FDP** *Flexor digitorum profundus* **FDS** *Flexor digitorum superficialis* **HyE** *Hypothenar eminence* **ME** *Medial epicondyle* **O** *Olecranon* **PaL** *Palmaris longus* **Ra** *Radius* **U** *Ulna* * *Under flexor carpi ulnaris*



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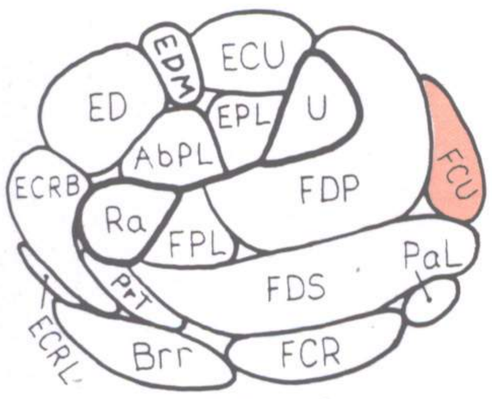

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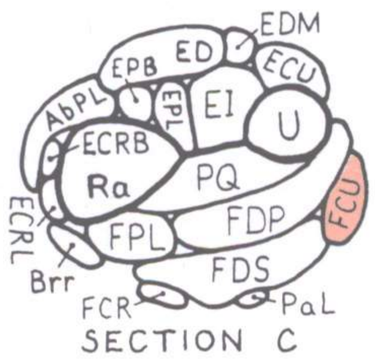

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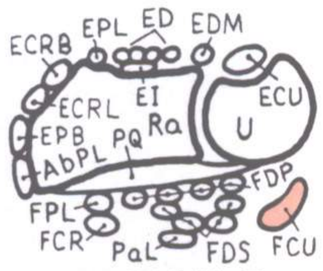


SECTION D

Flexor Carpi Ulnaris

ORIGIN *Humeral head:* Medial epicondyle of the humerus (by the common flexor tendon). *Ulnar head:* Medial border of the olecranon, continuing down the upper two-thirds of the posterior border of the ulna.

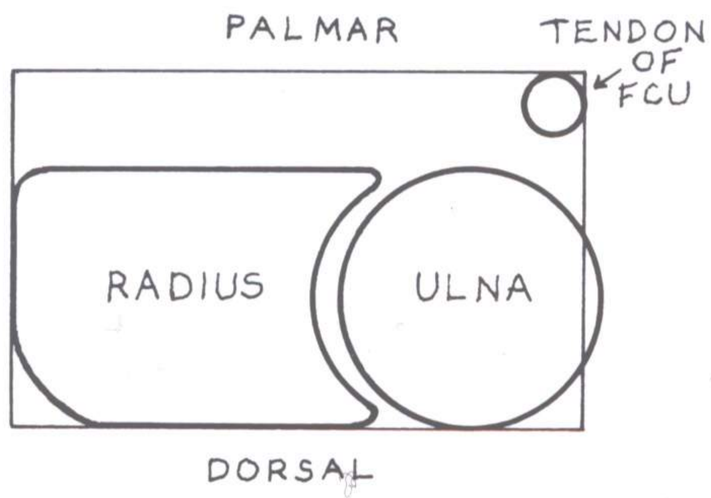
INSERTION Pisiform bone of the wrist.

ACTION Flexion and ulnar deviation of the hand at the wrist joint.

STRUCTURE The humeral and ulnar heads of the flexor carpi ulnaris combine to form a single *flat* belly which is extremely difficult to isolate on the surface. Basically, this muscle adds bulk to the general form of the flexor muscle mass on the forearm. The belly of the flexor carpi ulnaris tapers distally as its muscle fibers insert along the ulnar edge of its tendon, almost all the way down to the insertion. The tendon is relatively prominent on the distal quarter of the forearm, but less so than the tendons of the palmaris longus and flexor carpi radialis. At the distal fifth of the forearm, when the wrist joint is straight or flexed, the tendon of the flexor carpi ulnaris does not lie in contact with the ulna, and the interval between them is filled with fat. When the wrist is extended, the tendon approaches the bone, and the fat is squeezed out. The tendon directly creates the inner front corner of the box of the wrist (in the anatomical position).

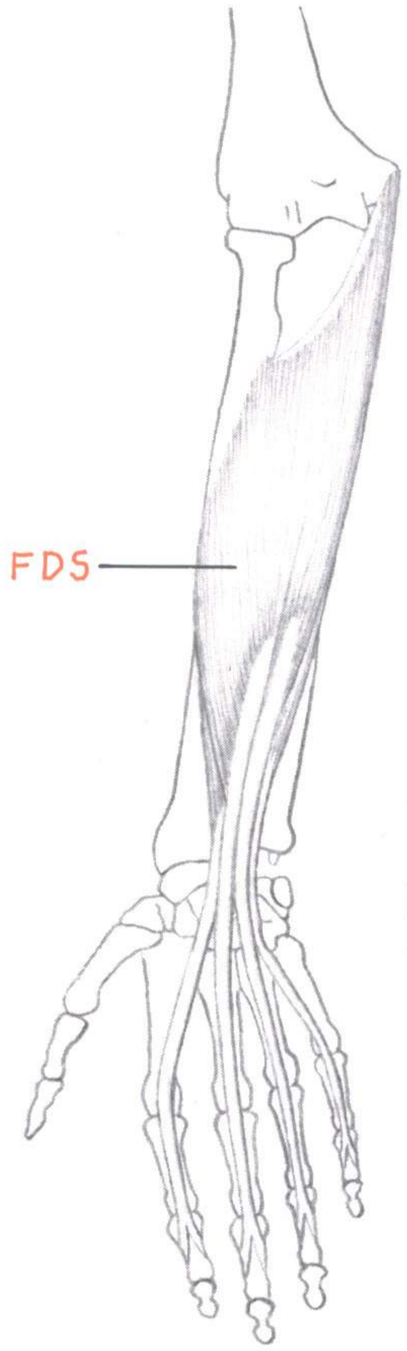
The ulnar edge of the proximal two-thirds of the belly of the flexor carpi ulnaris thins into an aponeurosis which in turn passes *over the surface* of the flexor digitorum profundus, to ultimately attach along the posterior border of the ulna. In other words, the flexor digitorum profundus is located in the interval between the *belly* of the flexor carpi radialis and the posterior border of the ulna, covered only by the thin aponeurosis of the flexor carpi ulnaris (which has no form of its own). The ulnar edge of the belly of the flexor carpi ulnaris may on rare occasion show up as a furrow. The basilic vein is at times located in the middle third of this furrow.

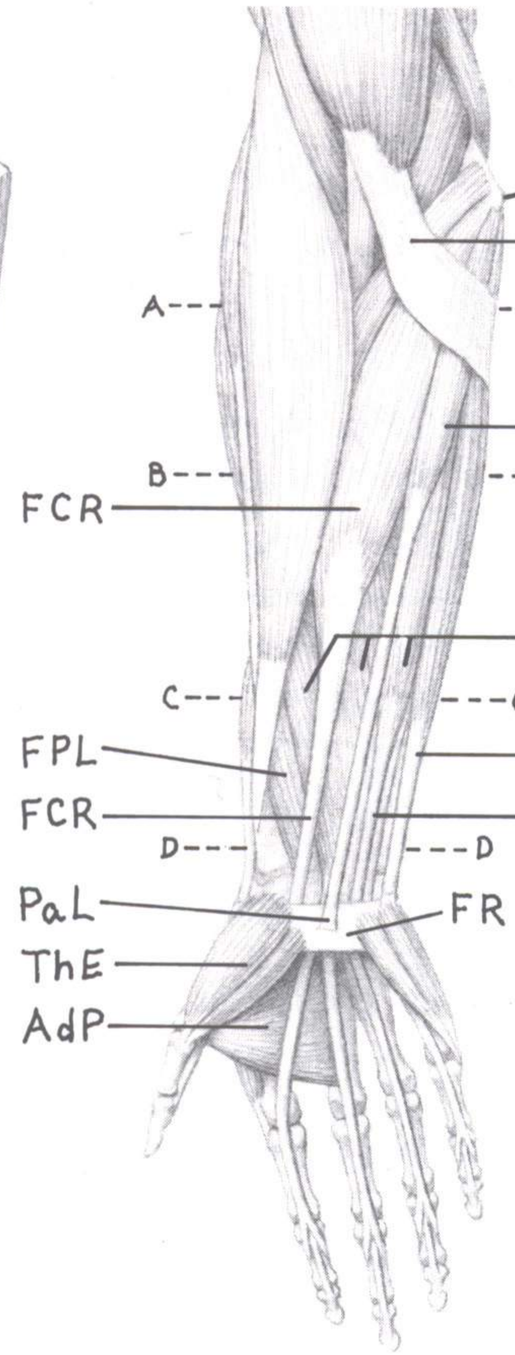
When the little finger is abducted, the abductor digiti minimi pulls on the pisiform bone. During this action, the flexor carpi ulnaris simultaneously contracts to stabilize the pisiform, and its tendon then becomes more prominent.

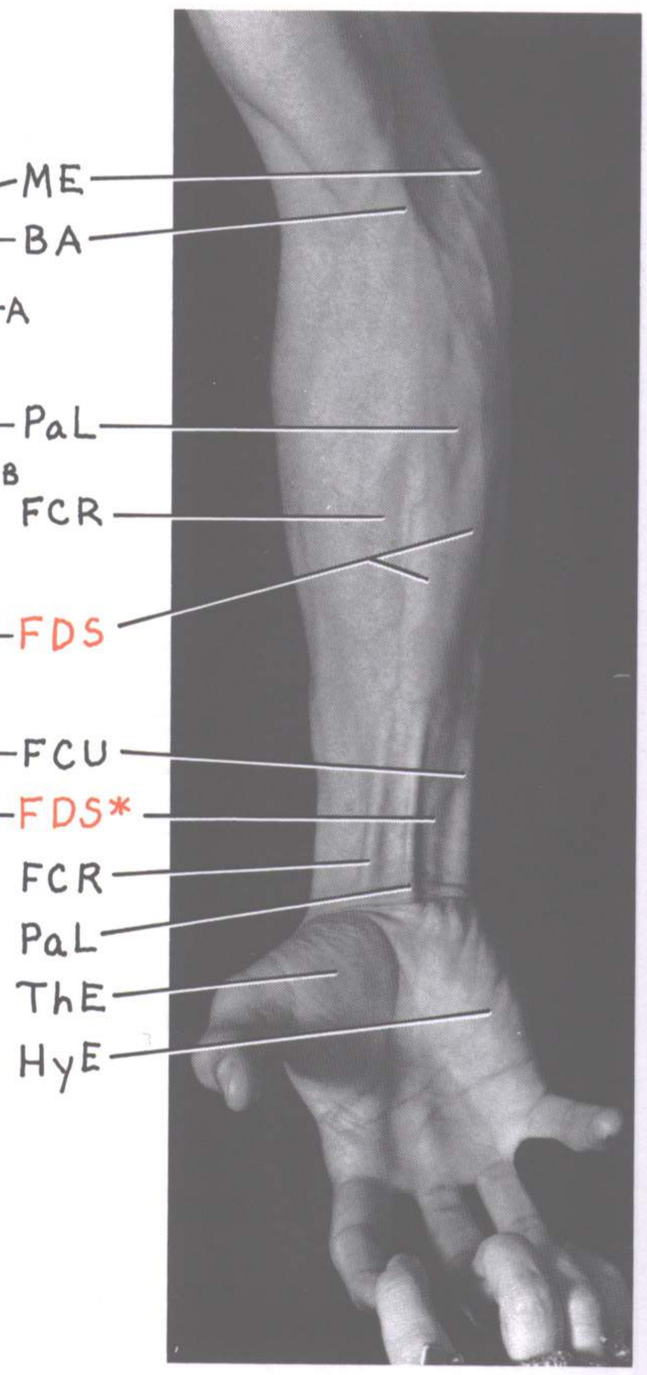


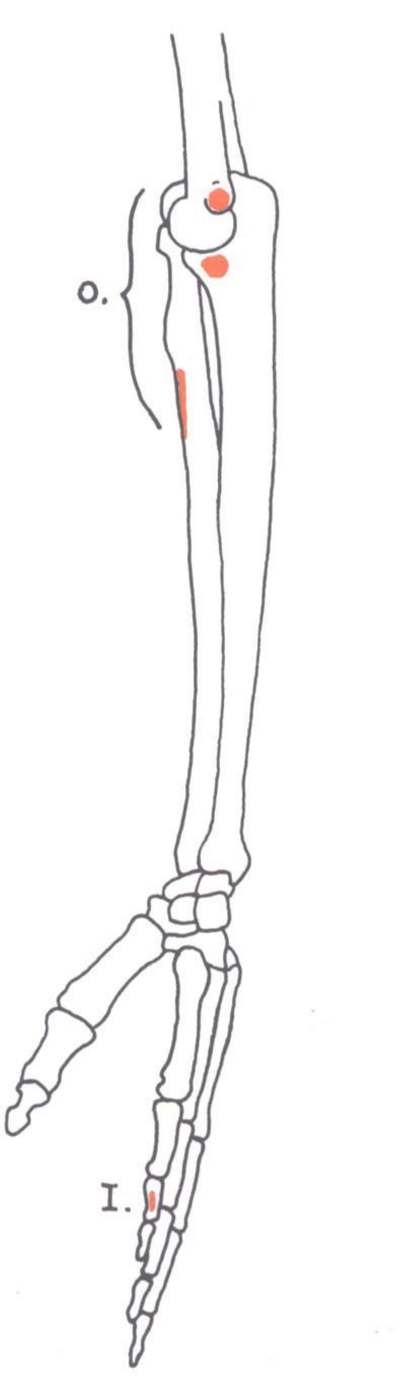
CROSS SECTION OF WRIST

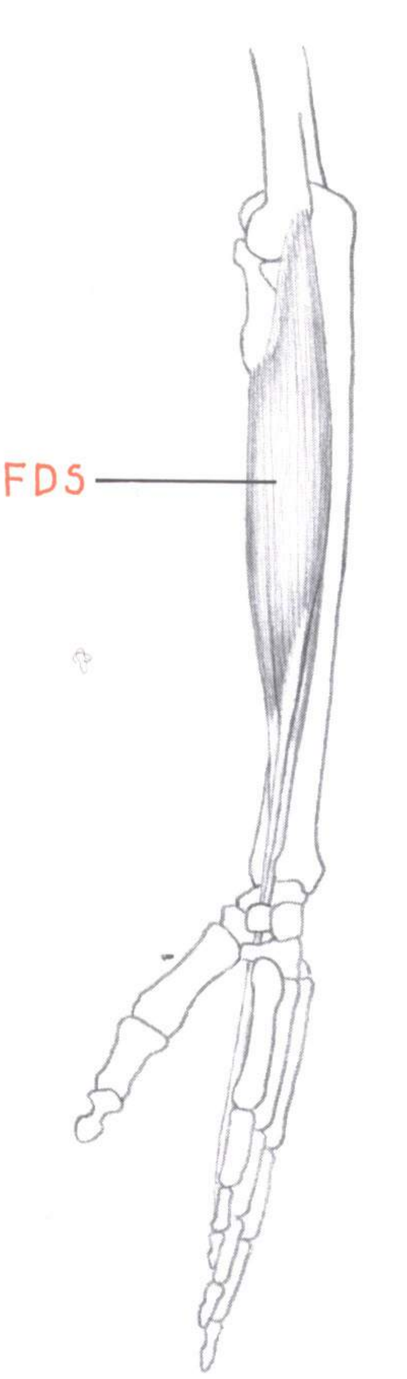
LAT. ⟷ MED.

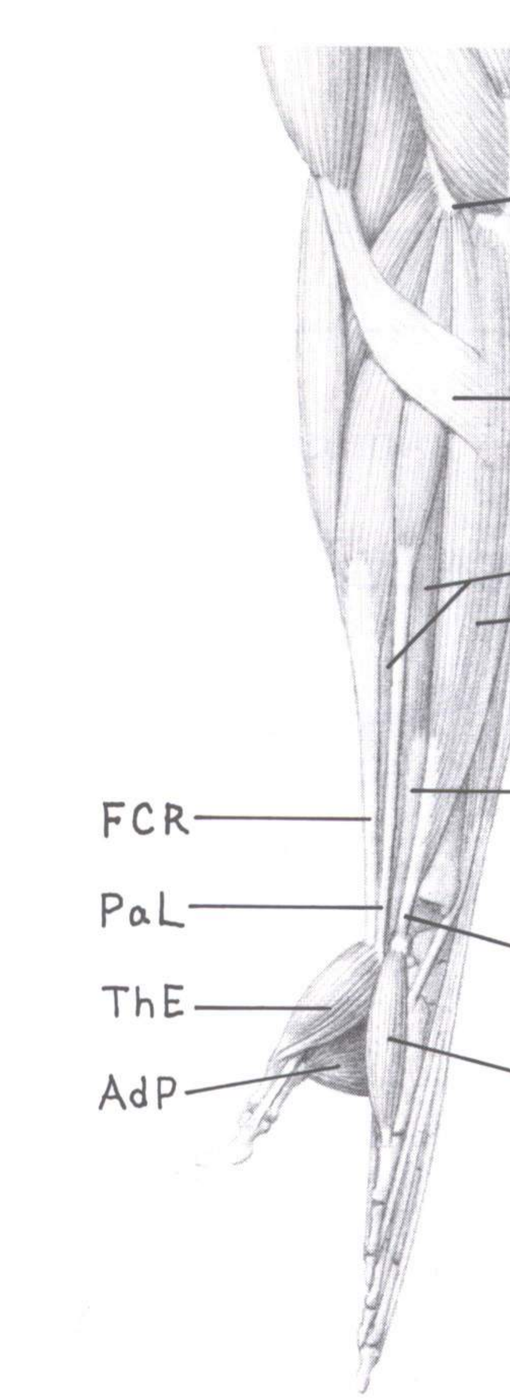


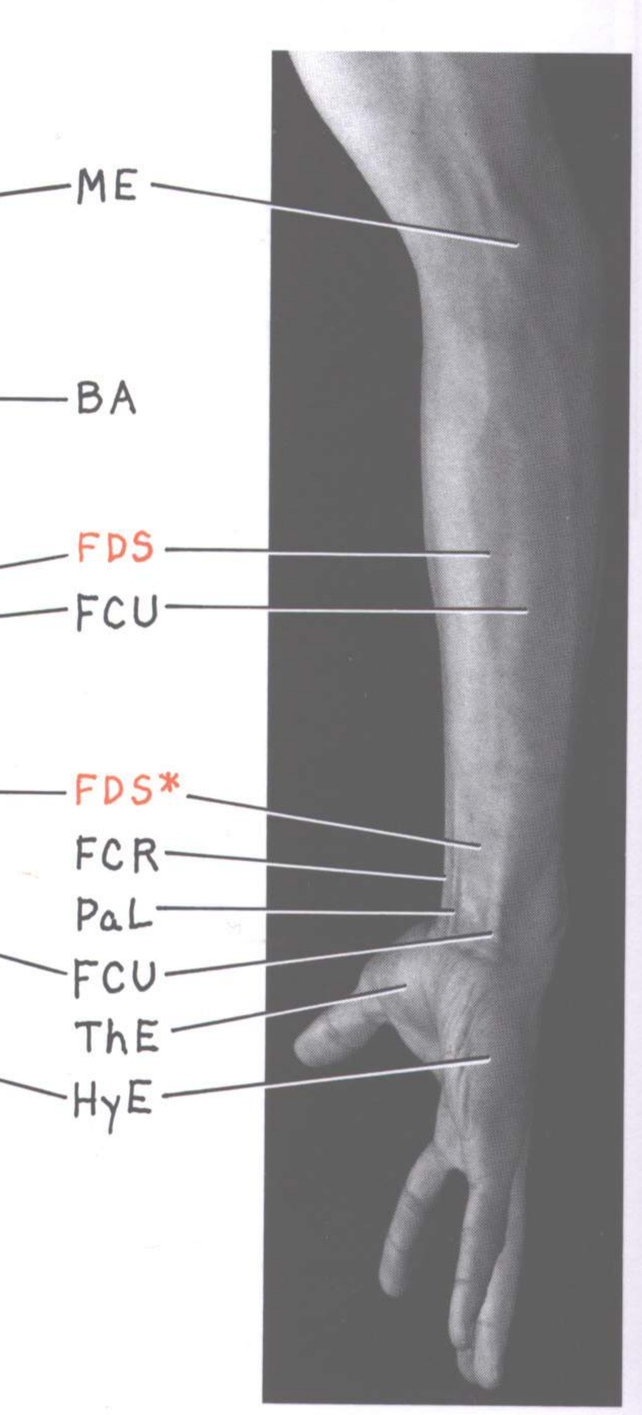




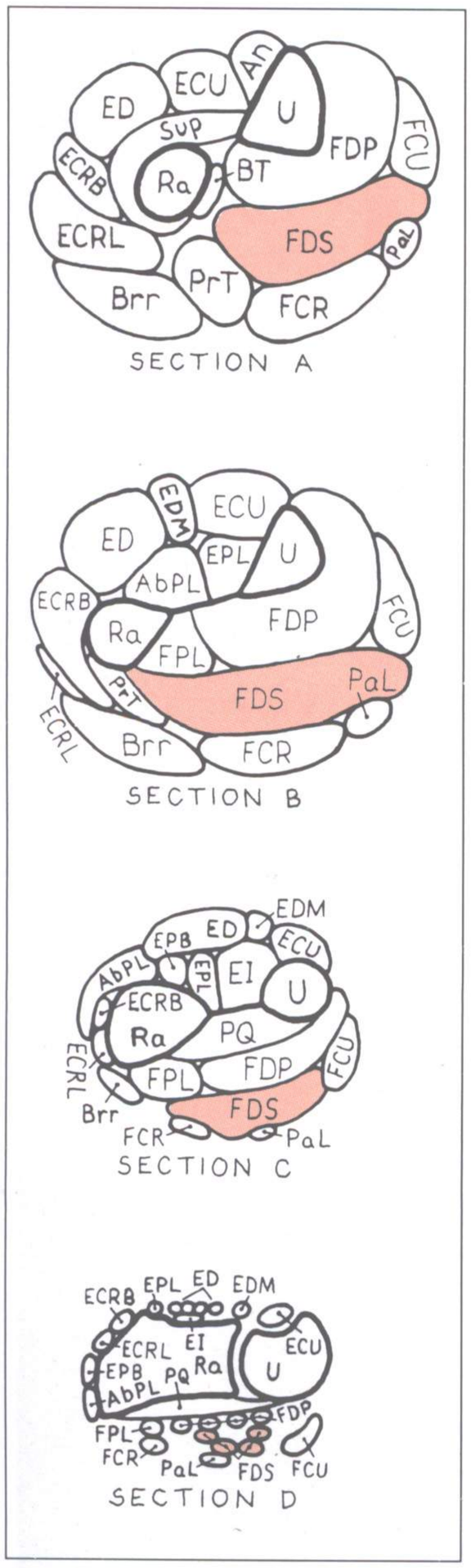








AdP *Adductor pollicis* **BA** *Bicipital aponeurosis* **FCR** *Flexor carpi radialis* **FCU** *Flexor carpi ulnaris*
FDP *Flexor digitorum profundus* **FDS** *Flexor digitorum superficialis* **FPL** *Flexor pollicis longus*
FR *Flexor retinaculum* **HyE** *Hypothenar eminence* **ME** *Medial epicondyle* **PaL** *Palmaris longus*
PrT *Pronator teres* **Ra** *Radius* **ThE** *Thenar eminence* **U** *Ulna* * *To ring finger*



Flexor Digitorum Superficialis (Flexor Digitorum Sublimis)

ORIGIN Originates from all three arm bones—humerus, ulna, and radius—as follows: the medial epicondyle of the **humerus** (by the common flexor tendon); the medial side of the coronoid process of the **ulna** and the ulnar collateral ligament of the elbow joint (the ligament connects the coronoid process of the ulna to the medial epicondyle of the humerus); and an oblique line on the anterior surface of the **radius,** beginning at the radial (bicipital) tuberosity and ending halfway down the bone.

INSERTION The edges of the palmar surfaces of the middle phalanges of the index, middle, ring, and little fingers (fingers two through five). It has no attachment to the thumb.

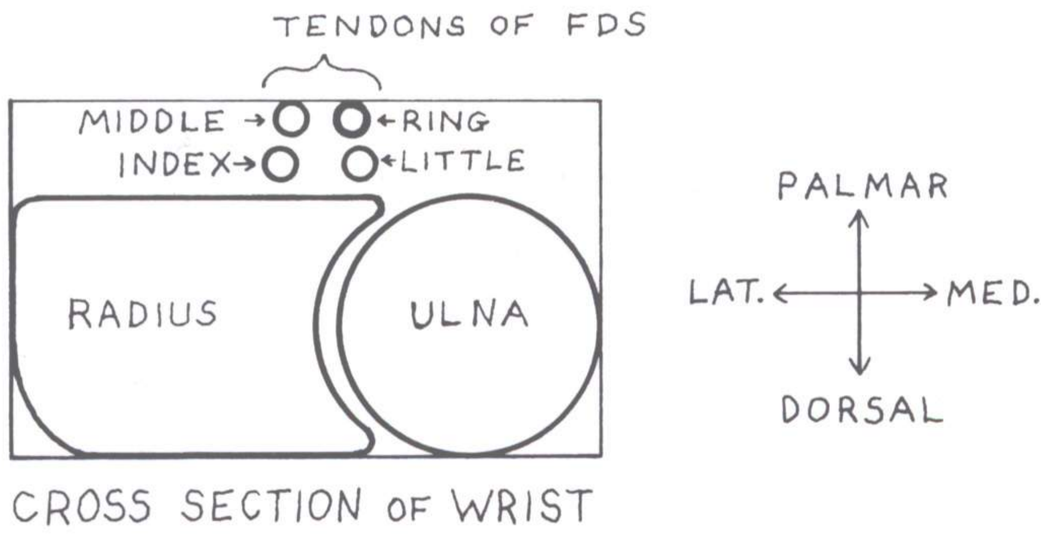
ACTION Flexes the middle phalanges of fingers two through five, and by continued action, flexes their proximal phalanges and then the wrist joint. It does not flex the distal phalanges.

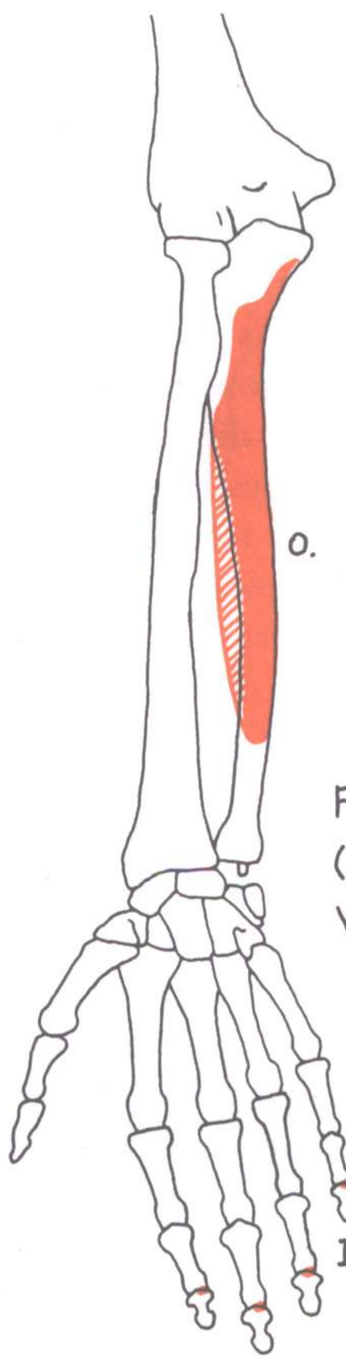
STRUCTURE The flexor digitorum superficialis is a wide, fairly large muscle layer in the forearm, mostly deep but partly superficial. The superficial part comes to the surface at several places, but can only occasionally be seen directly, when the fist is clenched, in the long narrow intervals between the flexor carpi radialis, palmaris longus, and flexor carpi ulnaris.

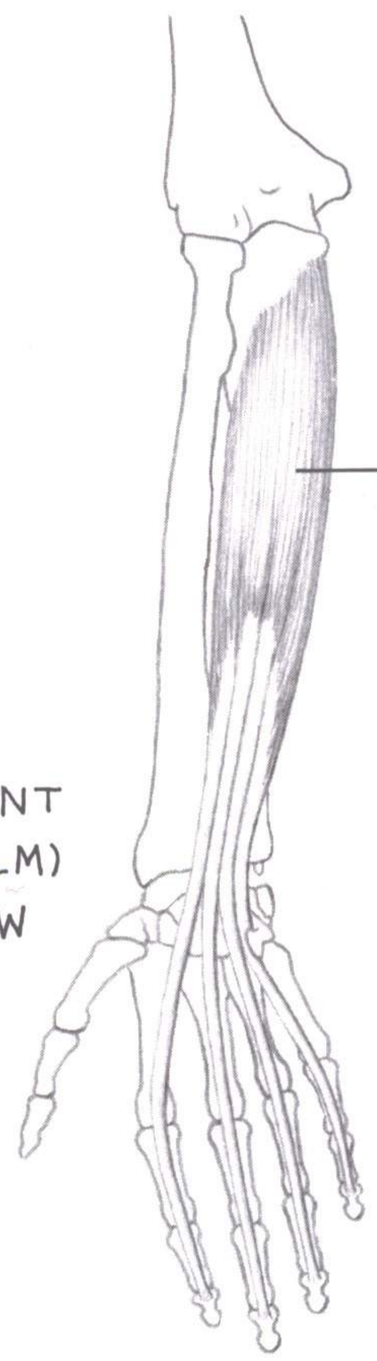
On the distal quarter of the forearm, the subcutaneous tendon of the flexor digitorum superficialis to the ring finger is usually easily seen, lying between the tendons of the palmaris longus and flexor carpi ulnaris. It is most readily seen when the hand is clenched into a fist and the wrist is slightly flexed. If the hand is then deviated toward the ulnar side, the tendon of the flexor digitorum superficialis to the middle finger slides laterally (toward the ulna) out from under the tendon of the palmaris longus.

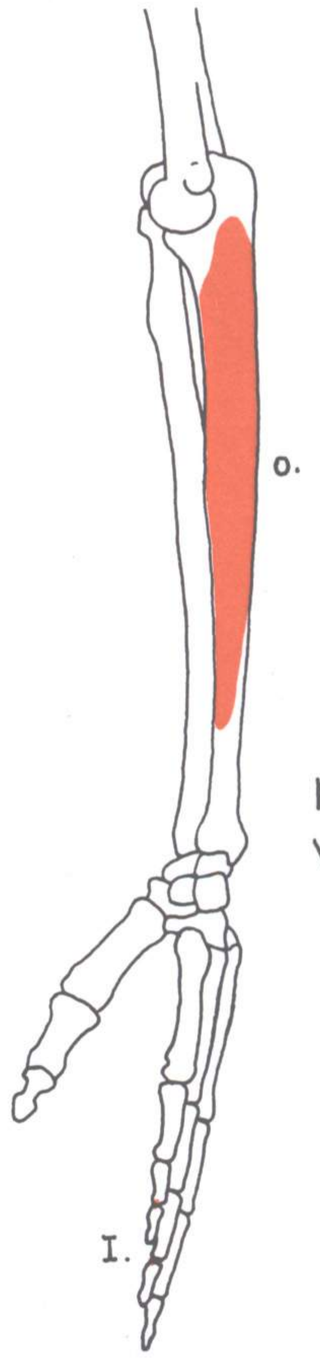
In the palm, the tendons of the flexor digitorum superficialis all lie on the same plane as they pass distally to their respective fingers. When the palmar fat is thin, and the fingers are partly flexed against resistance, these tendons may be seen in relief on the palm, radiating from the wrist toward the fingers.

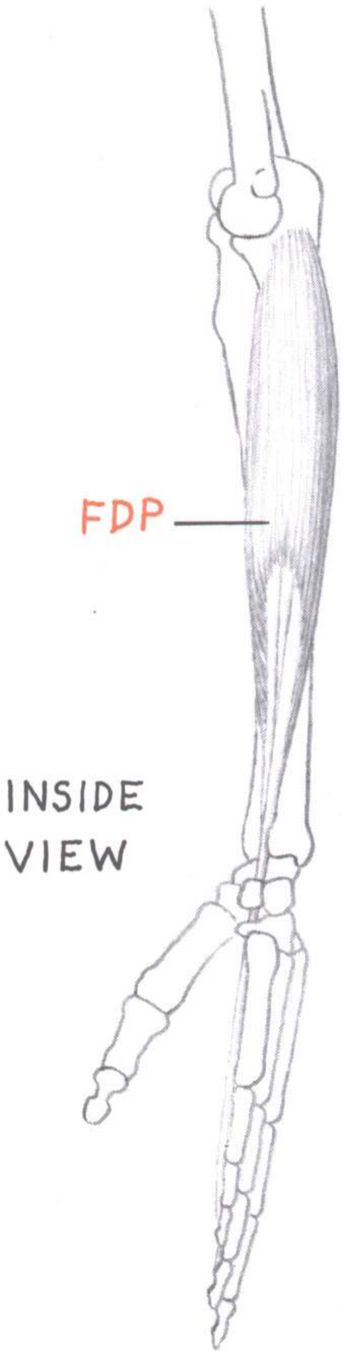
When the wrist is fixed in the straight position and the fingers are repeatedly flexed and extended, the belly of the flexor digitorum superficialis can be seen sliding up and down the lower portion of the forearm. Because the flexor digitorum profundus is also working during these actions, both these finger flexors influence the shape of the forearm—they thicken the upper mass of the forearm during finger flexion (they get shorter and thicker when they contract).

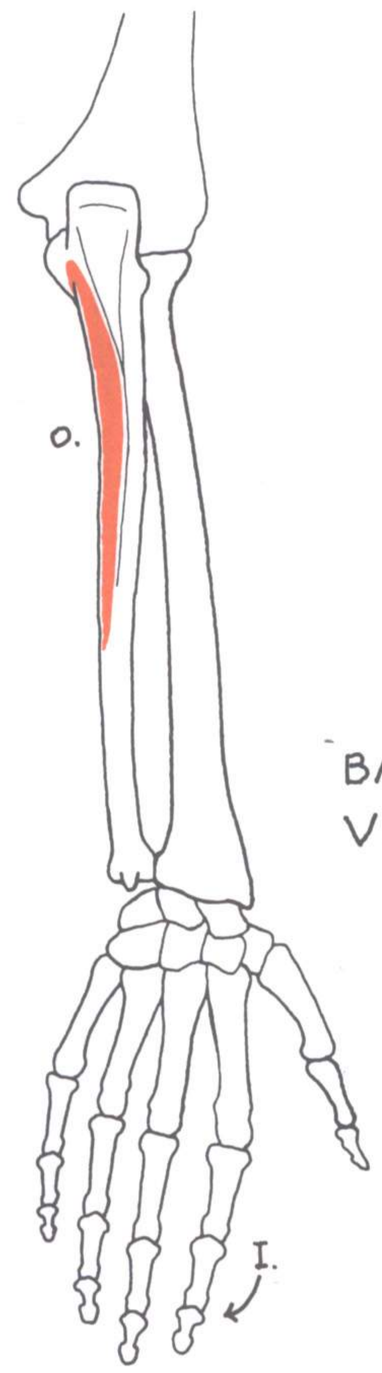


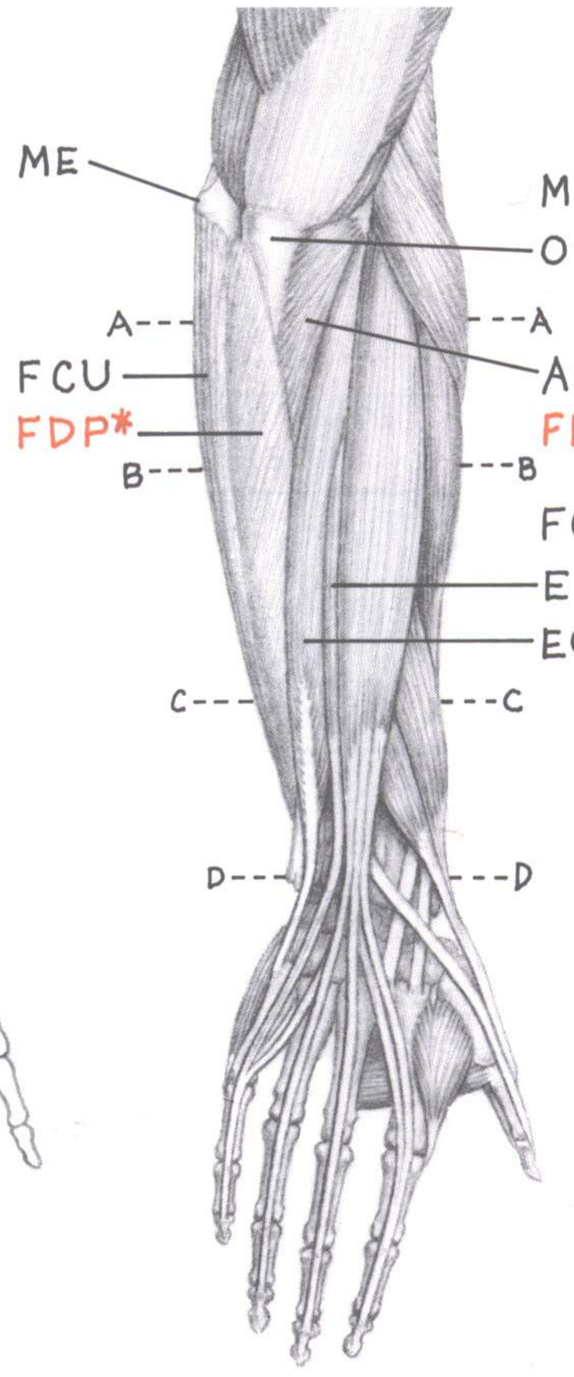


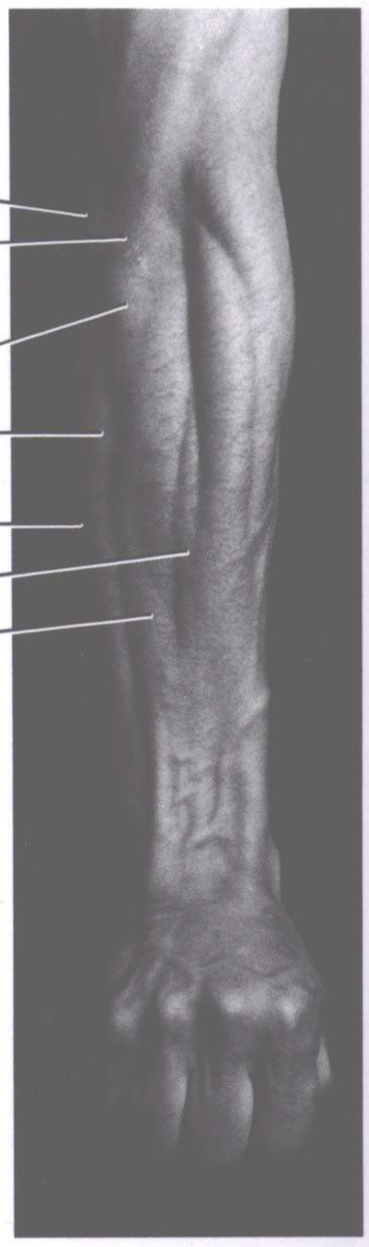




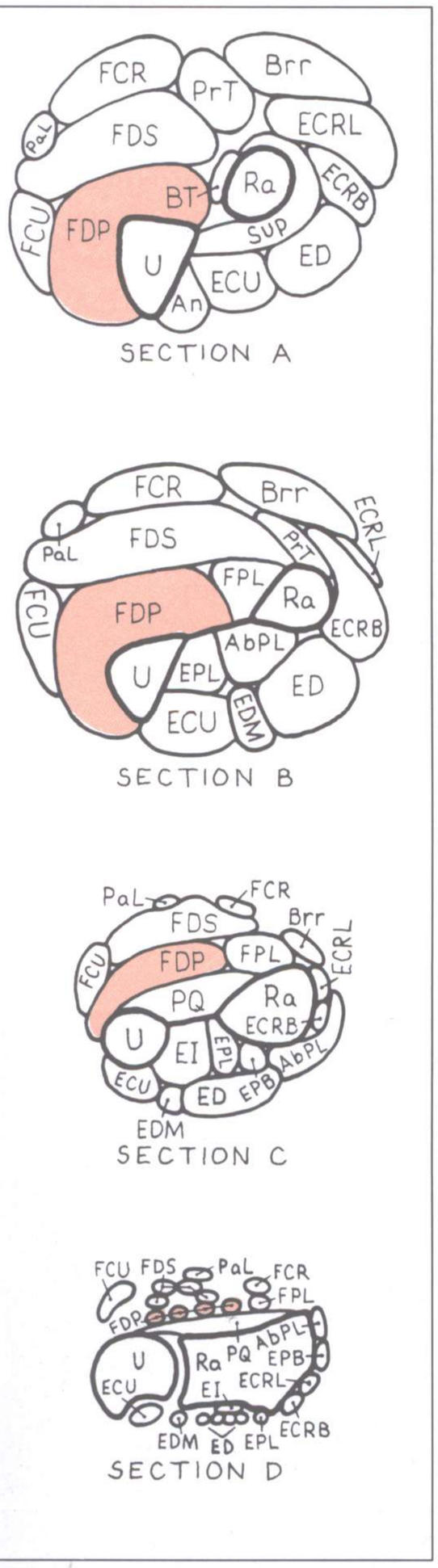








An *Anconeus* **BT** *Biceps tendon* **ECU** *Extensor carpi ulnaris* **EDM** *Extensor digiti minimi*
FCU *Flexor carpi ulnaris* **FDP** *Flexor digitorum profundus* **FDS** *Flexor digitorum superficialis*
FPL *Flexor pollicis longus* **ME** *Medial epicondyle* **O** *Olecranon* **PaL** *Palmaris longus*
PQ *pronator quadratus* **Ra** *Radius* **U** *Ulna* * *Under flexor carpi ulnaris*



Flexor Digitorum Profundus

ORIGIN Extensive, continuous area on the ulna—from the middle third of its posterior border, the upper three-fourths of its medial surface (exclusive of its uppermost one inch), and the middle third of its anterior surface. It also originates from the adjacent ulnar half of the interosseous membrane. (It does not originate from the radius or the humerus.)

INSERTION Palmar aspect of the base of the distal phalanges of the index, middle, ring, and little fingers (fingers two through five). It has no attachment to the thumb.

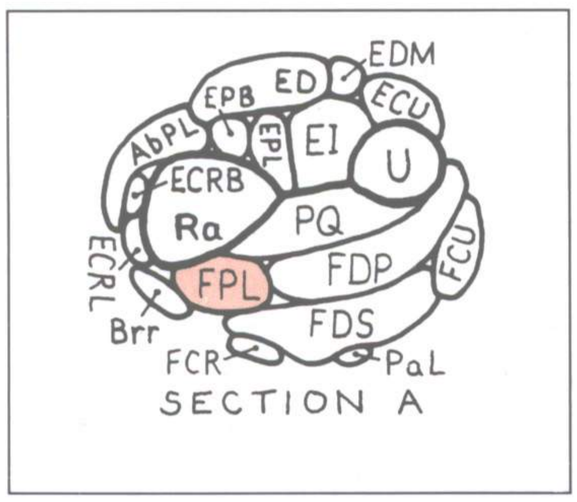
ACTION Powerfully flexes the distal phalanges of fingers two through five, and by continued action, flexes the other finger joints, as well as the wrist.

STRUCTURE Situated for the most part deep in the forearm, the flexor digitorum profundus is the largest of the forearm muscles and adds substantially to the volume of the flexor muscle mass. At the wrist, its four tendons lie deep to the other tendons of the forearm. A portion of its belly lies just under the thin aponeurotic expansion of the flexor carpi ulnaris, and actually produces surface form along the flexor side of the posterior border of the ulna.

This superficial strip of flexor digitorum profundus belly may on occasion be distinctly seen on the surface as a narrow form, tapering inferiorly, on the upper two-thirds of the back of the forearm. It is located between the posterior border of the ulna (and the medial side of the olecranon) and the edge of the *muscle fibers* of the flexor carpi ulnaris. It is most likely to be seen when the forearm is pronated, the wrist extended, and the fingers repeatedly flexed and extended. Whether or not this portion of the flexor digitorum profundus is distinctly seen on the surface, it, not the flexor carpi ulnaris, is responsible for directly creating the form of the flexor mass immediately adjacent to the posterior border of the ulna.

In the middle third of the forearm, the flexor muscles (specifically the flexor digitorum profundus) are separated from the extensor muscles (specifically the extensor carpi ulnaris) by a furrow, at the bottom of which lies the posterior border of the ulna.

When the wrist is fixed in the straight position and the fingers are repeatedly flexed and extended, the bellies of the flexor digitorum profundus and superficialis influence the shape of the forearm. When they contract to flex the fingers, they enlarge the medial side of the proximal half of the forearm as they shorten and thicken.



Flexor Pollicis Longus

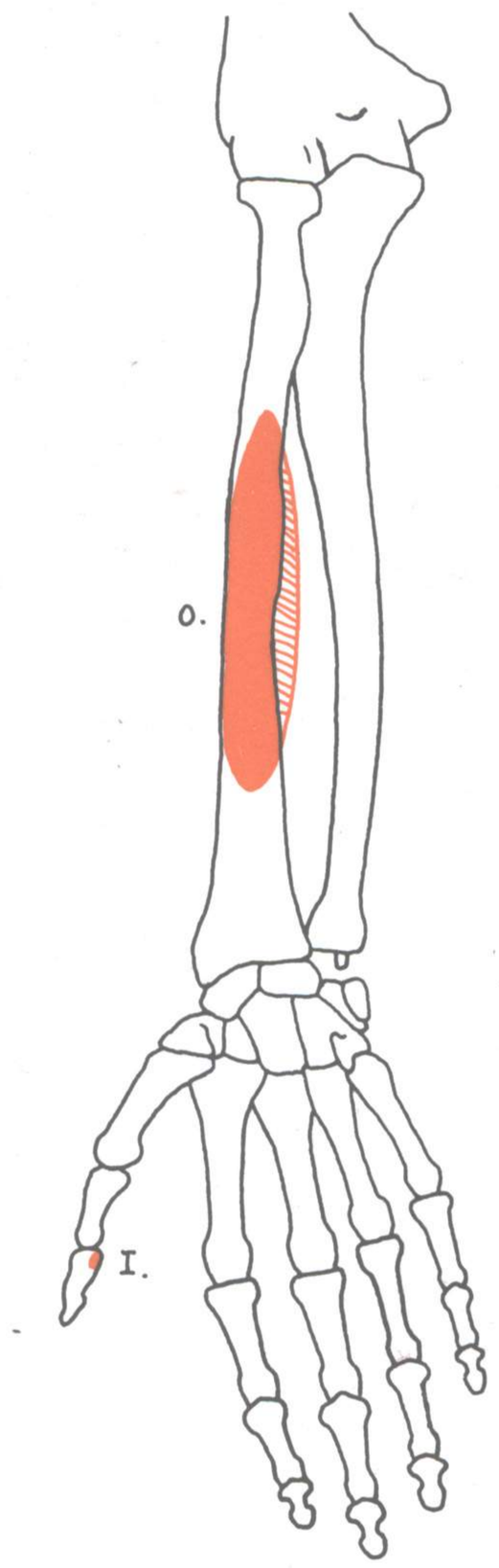
ORIGIN Middle half of the anterior surface of the radius and the adjacent interosseous membrane.

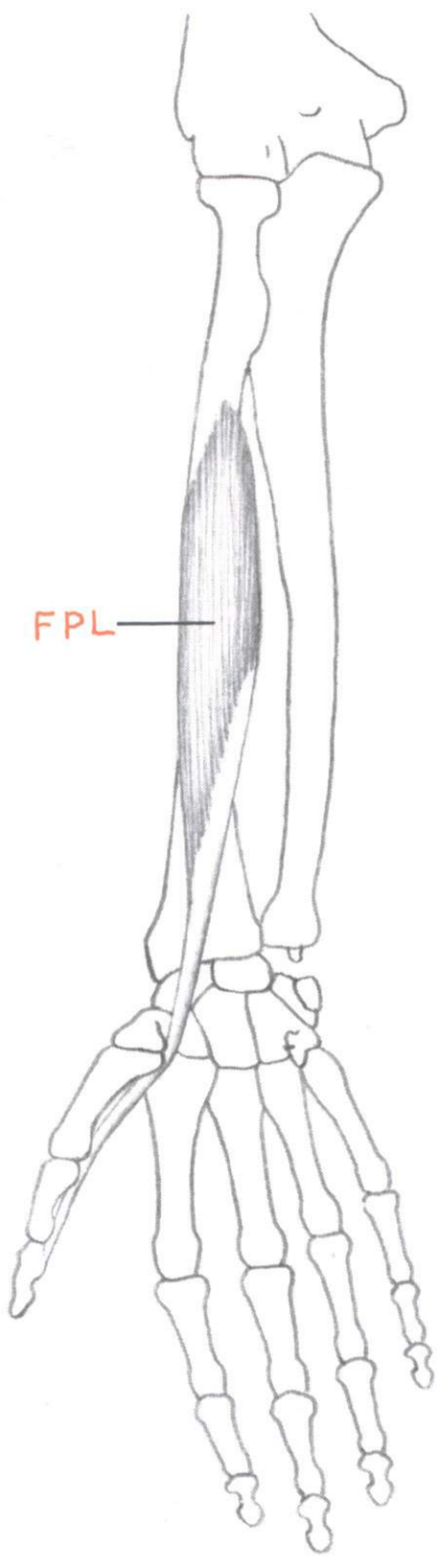
INSERTION Palmar aspect of the base of the distal phalanx of the thumb.

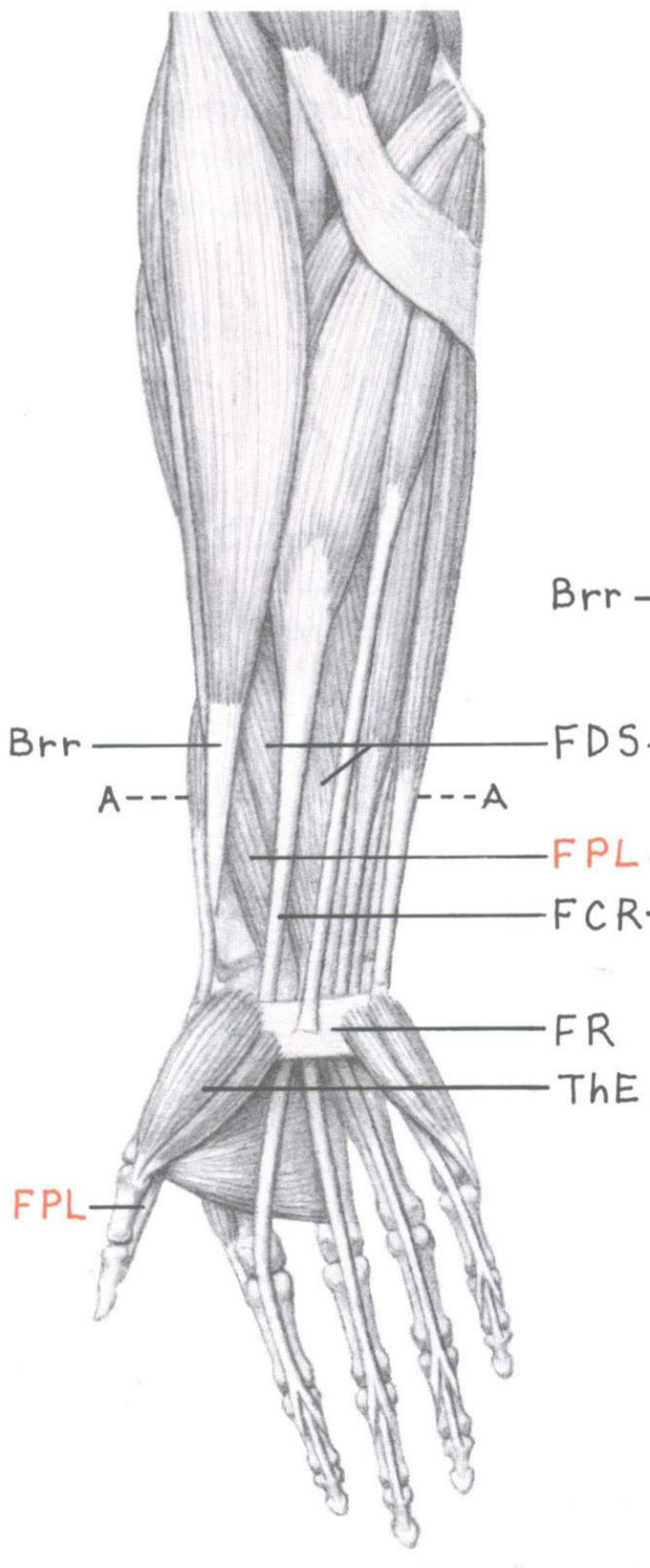
ACTION Flexes the distal phalanx of the thumb.

STRUCTURE The flexor pollicis longus is situated for the most part deep in the forearm, where it adds some fullness on the anterior surface of the radius. It becomes partially superficial on the front of the lower half of the forearm. Never distinct, the belly of the flexor pollicis longus can be seen moving in this area as the distal phalanx of the thumb is flexed and extended. When the interphalangeal joint of the thumb is flexed, the belly shortens, and a slight depression forms a short distance proximal to the wrist as the distal end of the belly slides upward. Also in this position, it will be noticed that the thickness (dorsal to palmar) of the proximal phalanx of the thumb has increased, caused by the pulling away of the tendon of the flexor pollicis longus from the phalanx.

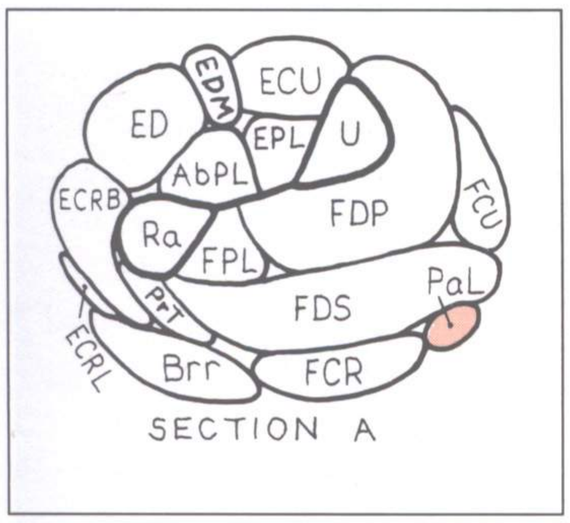
The flexor pollicis longus therefore very subtly affects surface form in two areas: on the front of the lower end of the forearm and on the proximal phalanx of the thumb.

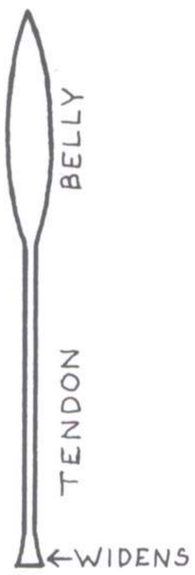






BA *Bicipital aponeurosis* **Brr** *Brachioradialis* **FCR** *Flexor carpi radialis* **FCU** *Flexor carpi ulnaris* **FDP** *Flexor digitorum profundus* **FDS** *Flexor digitorum superficialis* **FPL** *Flexor pollicis longus* **FR** *Flexor retinaculum* **HyE** *Hypothenar eminence* **ME** *Medial epicondyle* **PaL** *Palmaris longus*





Palmaris Longus

ORIGIN Medial epicondyle of the humerus (by the common flexor tendon).

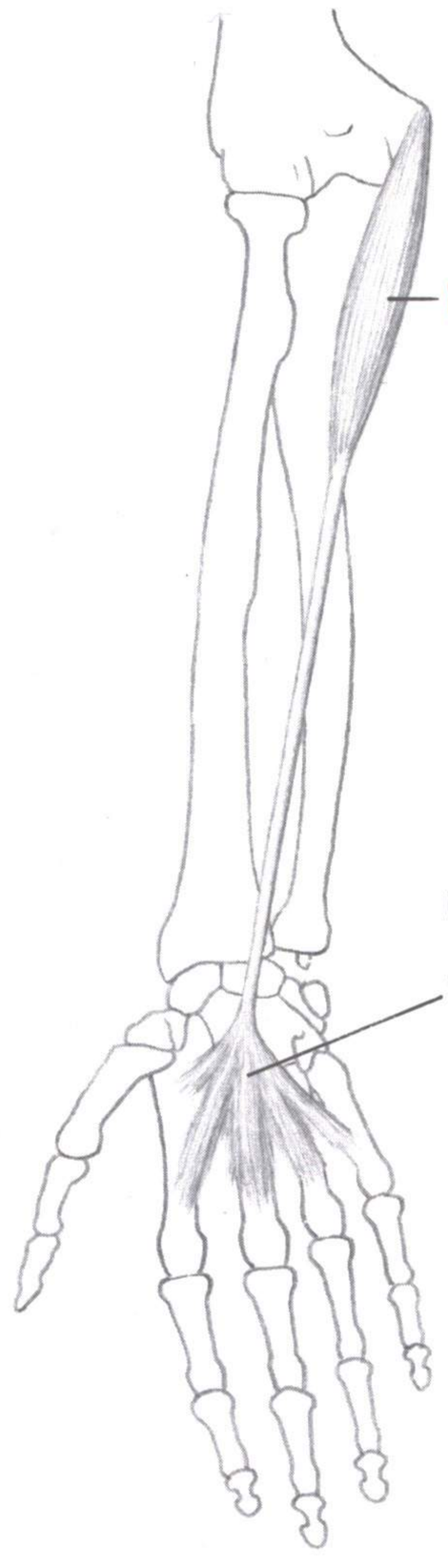
INSERTION Distal part of the flexor retinaculum of the wrist and the apex of the palmar aponeurosis.

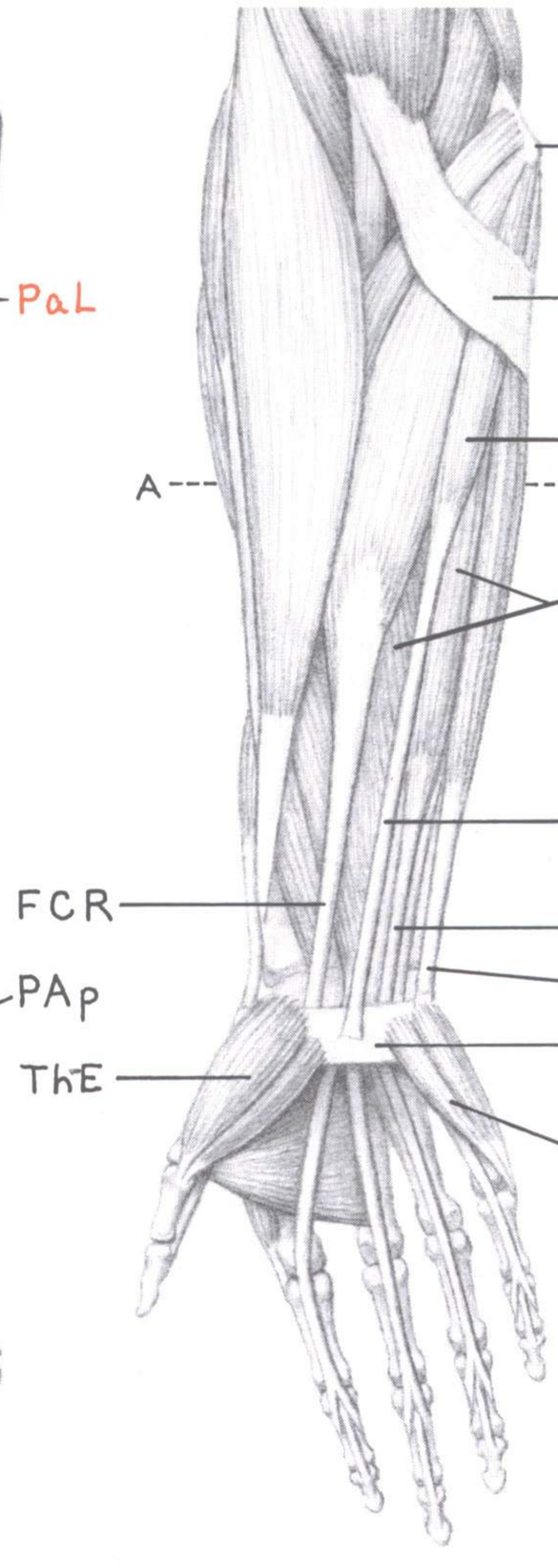
ACTION Flexes the hand at the wrist.

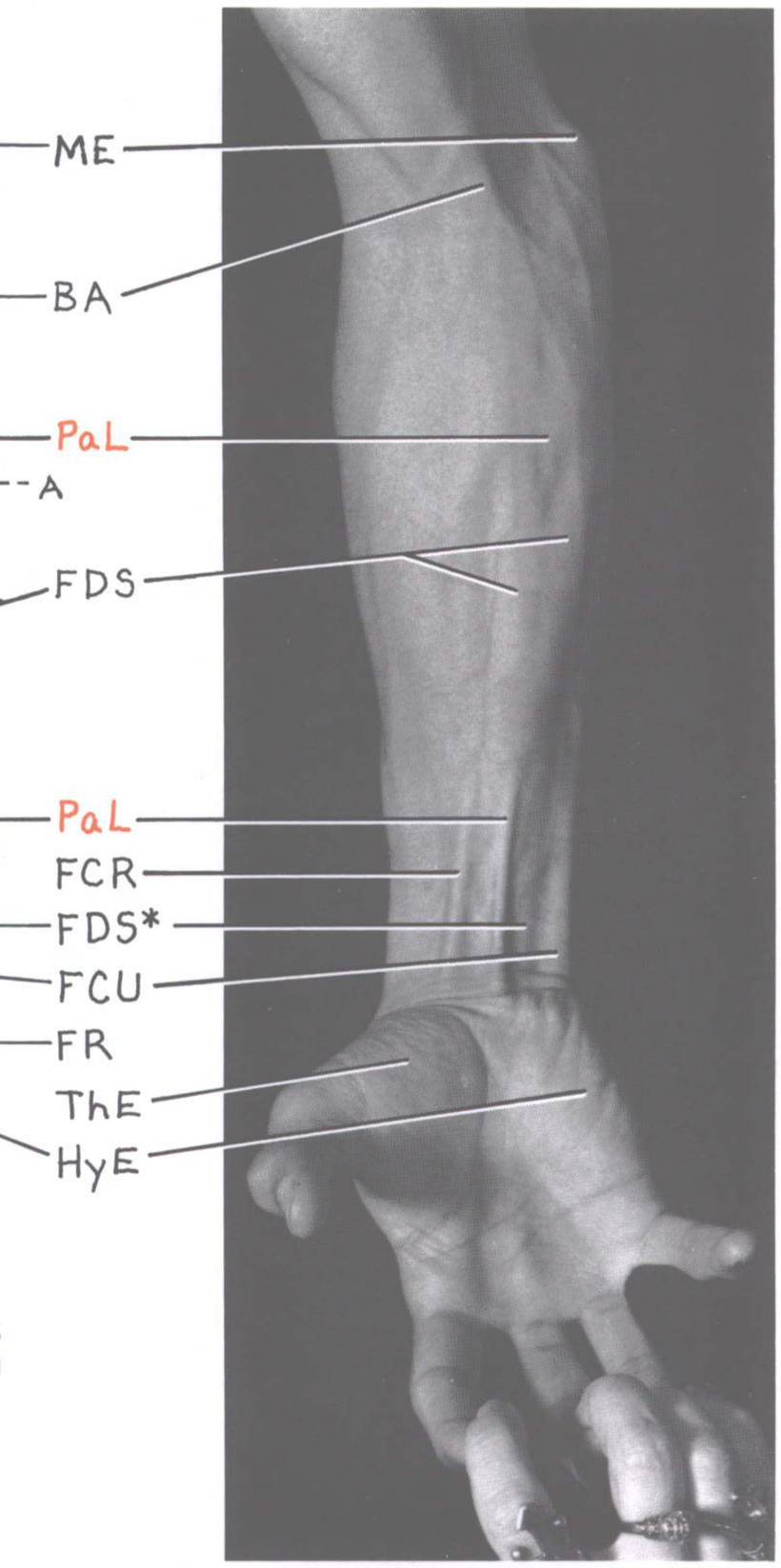
STRUCTURE The palmaris longus consists of a short, narrow, fusiform muscle belly proximally and its very long, slender, slightly flattened tendon. Its belly may be seen only rarely as a *short* elliptical relief descending from the medial epicondyle of the humerus. The tendon can easily be seen passing down the *middle* of the lower two-thirds of the anterior (flexor) aspect of the forearm. It widens slightly just as it reaches the base of the hand. This tendon is the most conspicuous tendon at the wrist; it becomes especially prominent when the wrist is partially flexed and the hand is clawed.

The tendon frequently sends a tendinous slip to the surface of the muscles of the thumb, which creates a subtle raised ridge on the thenar eminence (on the abductor pollicis brevis) when the thumb is abducted.

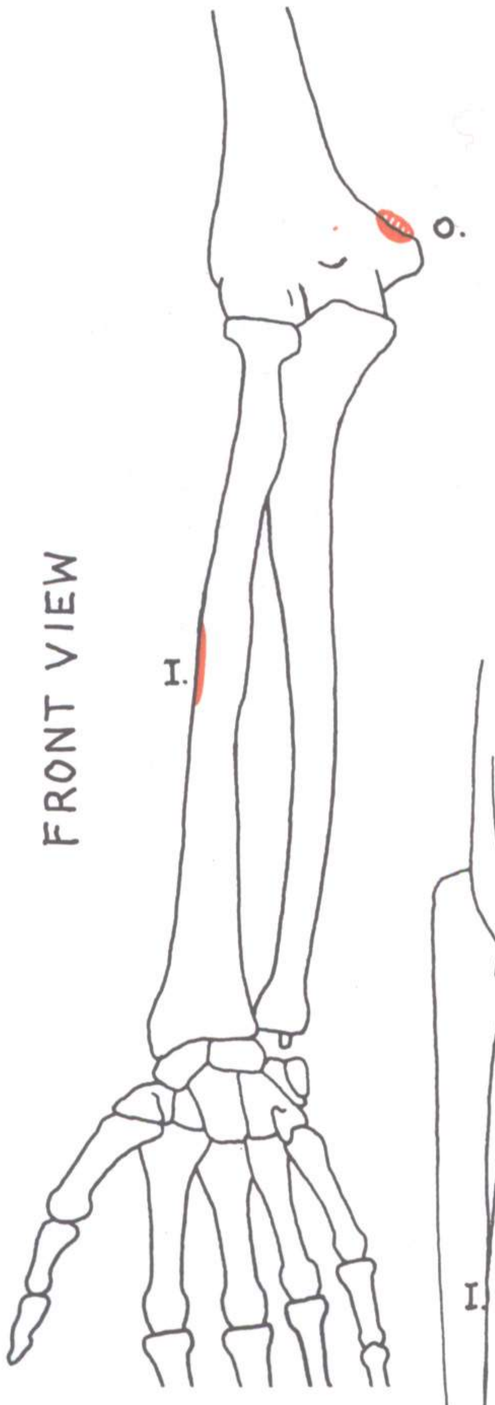
The palmaris longus is reported to be absent in approximately twelve percent of the population.

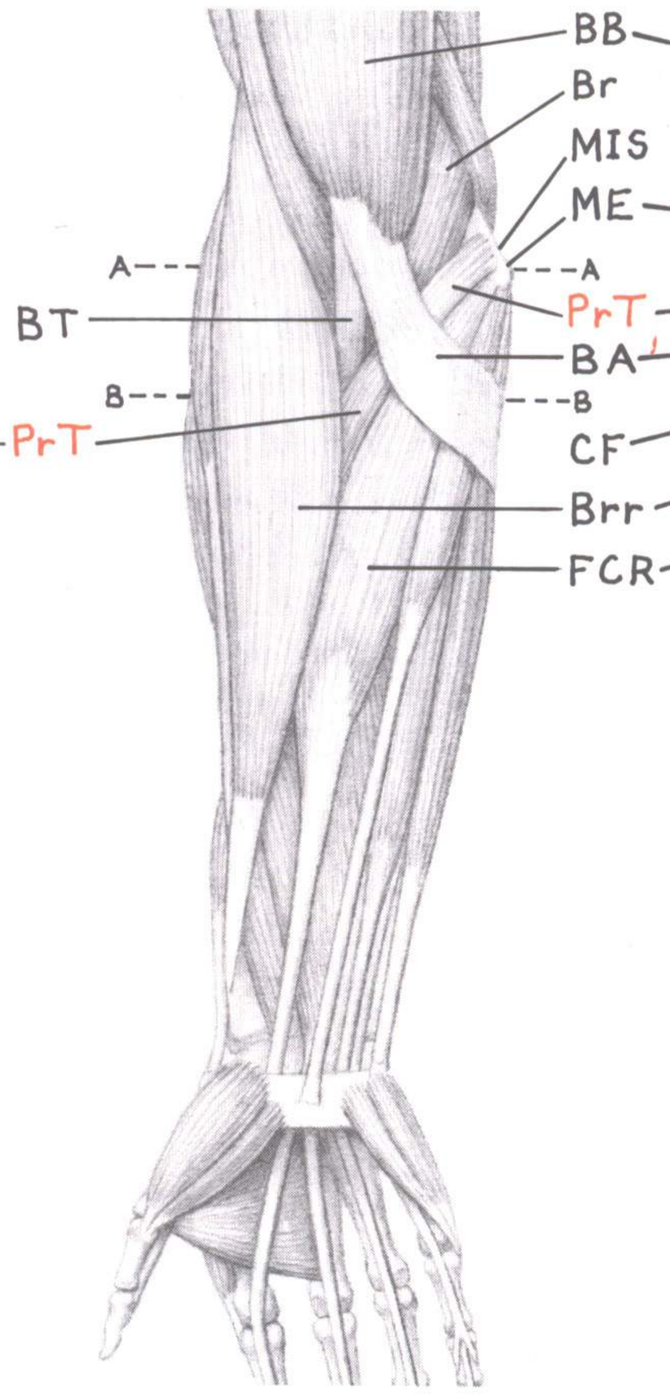


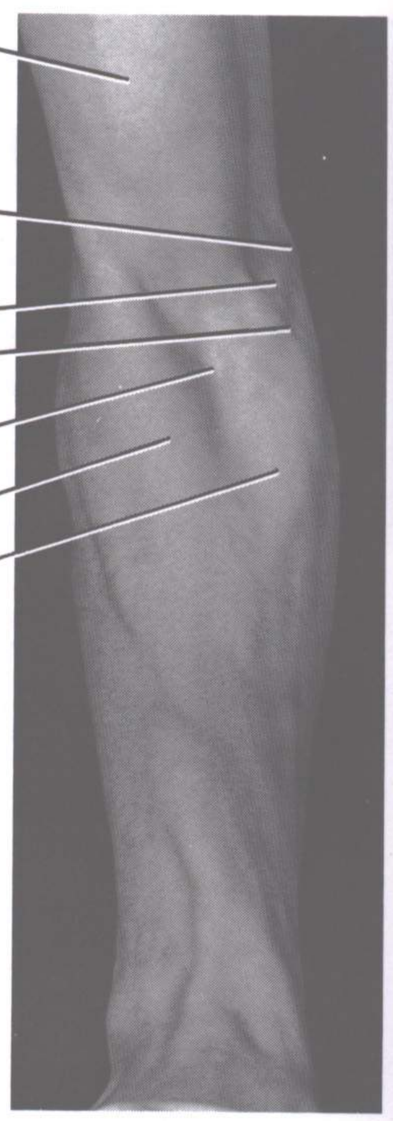




PAp *Palmar aponeurosis* **PQ** *Pronator quadratus* **Ra** *Radius* **ThE** *Thenar eminence* **U** *Ulna*
* *To ring finger*

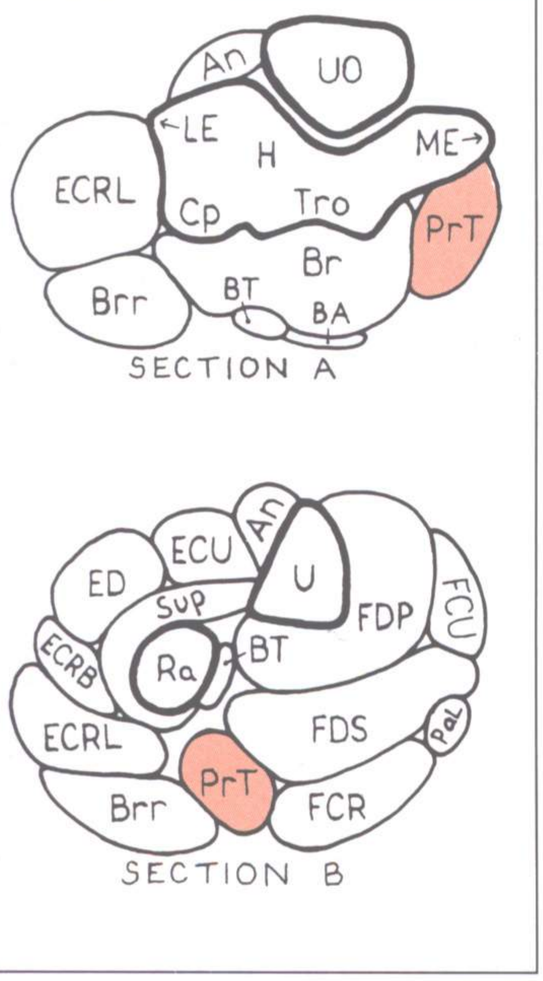






ELBOW FLEXED, FOREARM PRONATED

BA *Bicipital aponeurosis* **BB** *Biceps brachii* **Br** *Brachialis* **Brr** *Brachioradialis* **BT** *Biceps tendon*
CF *Cubital fossa* **FCR** *Flexor carpi radialis* **FDS** *Flexor digitorum superficialis* **H** *Humerus*
ME *Medial epicondyle* **MIS** *Medial intermuscular septum* **PrT** *Pronator teres* **Ra** *Radius*
TMe *Triceps—medial head* **U** *Ulna*



Pronator Teres

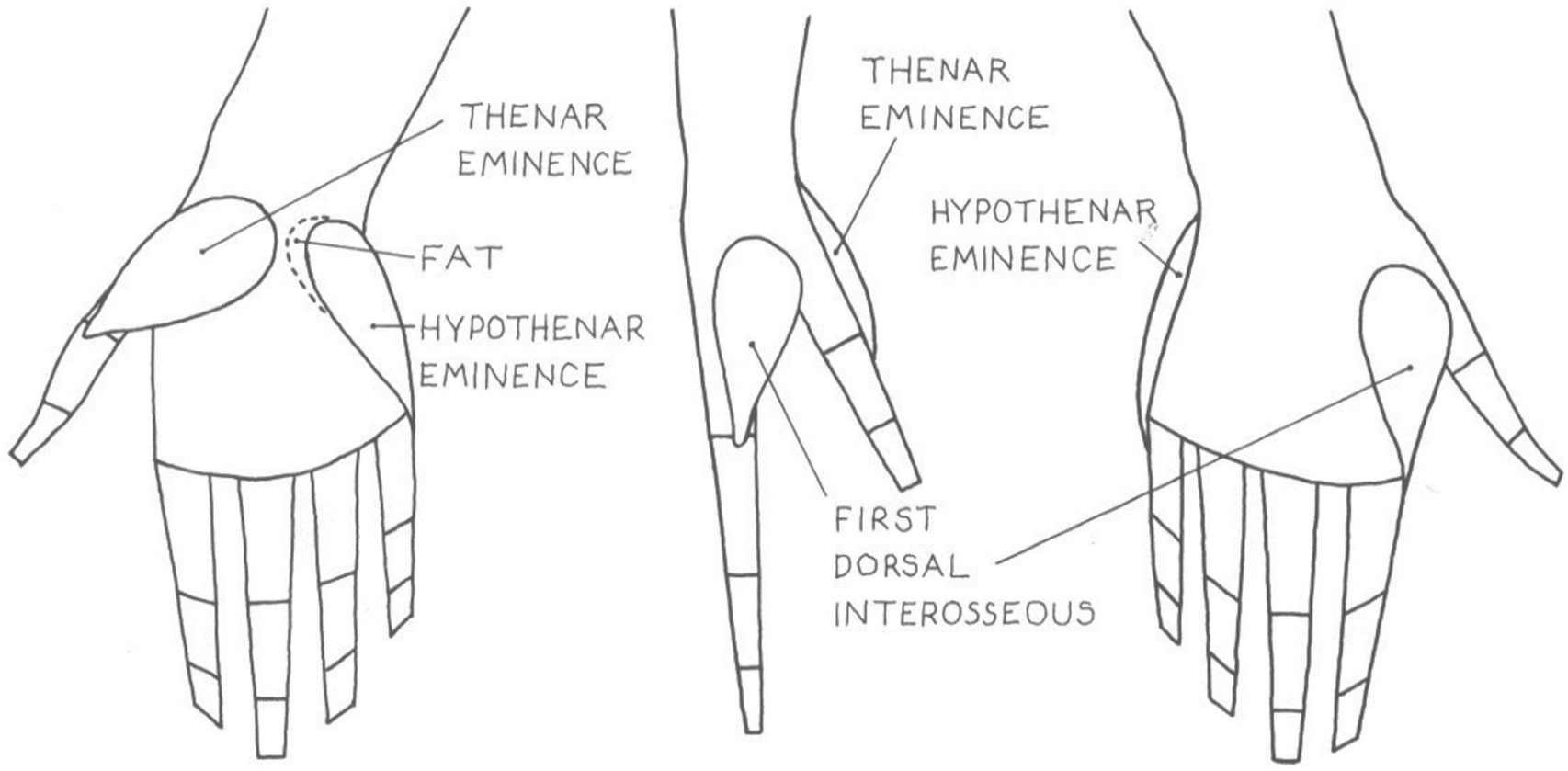
ORIGIN The medial epicondyle of the humerus and the adjacent anterior surface of the bone. The origin is located immediately proximal to the origin of the common flexor tendon of the forearm flexors. It also originates from the common flexor tendon itself, as well as from the medial intermuscular septum of the upper arm.

INSERTION A short, rough, vertical line located halfway down the lateral surface of the radius (at its point of maximum convexity).

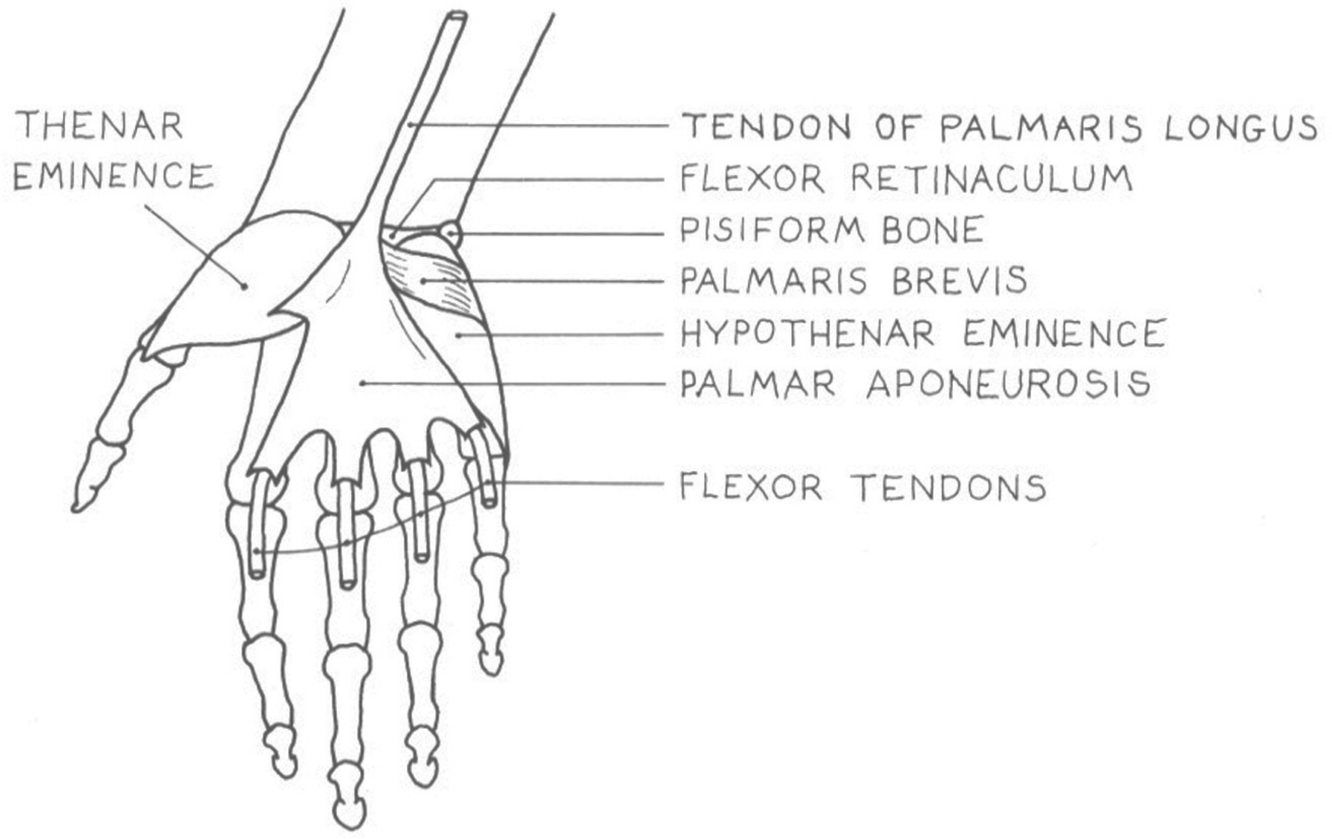
ACTION Pronates the forearm; assists in flexing the elbow joint.

STRUCTURE The pronator teres is a short, fleshy, cylindrical muscle which begins slightly higher than, and then contributes to, the flexor mass on the forearm. The distal end of its belly, covered by the brachioradialis, ends in a flat tendon before inserting. Although the pronator teres is for the most part superficial, it is difficult to see in isolation; its oblique form is most likely to be seen when the elbow is partially flexed, the forearm pronated, the wrist fully extended, and all the muscles tensed. It is separated from the brachioradialis by a small triangular interval, the **cubital fossa,** best seen in the aforementioned position.

The form of the pronator teres is not affected by the constricting action of the bicipital aponeurosis. The ulnar head of this muscle is small and deep; it has no effect on surface form.



3 TEARDROP MUSCLE MASSES OF HAND
(RIGHT HAND)



PALM VIEW - RIGHT HAND

The Hand Muscles

The **extrinsic muscles** of the *HAND*, or manus, are those muscles that arise on the upper arm and forearm and insert into the hand. Only their tendons are located on the hand. These muscles are described in the forearm section. The **intrinsic muscles** of the hand arise on the hand itself, and their bellies and short tendons are located in the hand. There are no muscle fibers present below (distal to) the metacarpophalangeal joints of the hand.

The back of the hand is mostly bony and tendinous, whereas the palm side is muscular and fatty. There are **three muscle masses of the hand:** the thenar eminence, hypothenar eminence, and first dorsal interosseous muscle; all are teardrop-shaped.

The muscle mass of the thumb, the **thenar eminence,** is made up of the abductor pollicis brevis, flexor pollicis brevis, and opponens pollicis. Slightly pointed distally, its teardrop- or egg-shaped mass constitutes the **ball of the thumb.** The thenar eminence, along with the metacarpal of the thumb, forms a conical volume. Proximally, it blends with the bony projection of the scaphoid bone of the carpus. Distally, the thenar muscles become tendinous before crossing the metacarpophalangeal joint; their muscular form ends before reaching the joint.

The abductor pollicis brevis is the largest muscle of the group—it slightly overlaps the flexor pollicis brevis and overlaps almost all of the opponens pollicis. The deep **opponens pollicis** adds to the bulk of the thenar mass; its very narrow superficial portion located between the metacarpal of the thumb and thenar eminence is not seen in life. The separations between the individual muscles of this eminence are not seen. The thenar eminence is wider and thicker than the hypothenar eminence.

Long and narrow, the hypothenar eminence is the muscle mass of the little finger. It is located on the outside of the palm and hand. The side of its elongated form extends around to the back of the hand, reaching the side of the metacarpal of the little finger. Distally, it inserts onto the *outside* of the little finger.

The hypothenar eminence consists of the abductor digiti minimi, flexor digiti minimi brevis, opponens digiti minimi, and palmaris brevis. The superficial abductor digiti minimi and flexor digiti minimi become tendinous before crossing the metacarpophalangeal joint; their muscular form ends before reaching the joint.

Only a narrow strip of the **opponens digiti minimi** is superficial at the palmar edge of the eminence. This muscle adds bulk to the hypothenar eminence, but its form is never seen, as it is covered by the palmar fat.

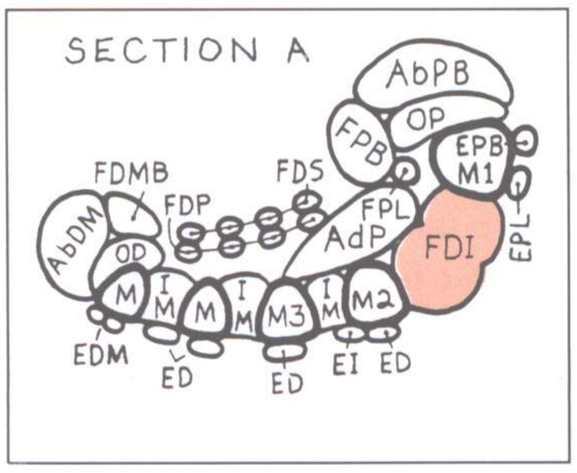
Because of the palmar fat, the inner edge of the hypothenar eminence is not distinct, but rather blends into the concavity of the palm. The hypothenar eminence forms the curved outer profile of the ulnar side of the hand, quite visible from the back view of the hand. Its form is slightly separate from the prominence of the pisiform bone, from which the abductor digiti minimi originates.

The **palmaris brevis** lies on the proximal half of the palmar surface of the thenar eminence. It originates from the anterior surface of the flexor retinaculum and the ulnar edge of the palmar aponeurosis and passes across the hypothenar eminence to insert into the skin on the ulnar border of the hand. This thin rectangular skin muscle pulls the skin of the ulnar edge of the palm toward the middle of the palm, increasing the thickness of the hypothenar eminence, which deepens the cupped hand. The individual muscles of the hypothenar eminence are not seen.

The muscles of the hypothenar eminence do not quite reach the midline of the base of the hand. However, the fatty cushion covering them does, bringing the teardrop form (muscle and fat) of the hypothenar eminence in contact with the thenar eminence at the midline.

The **palmar aponeurosis** is a triangular sheet of tendinous fibers which lies on the palm, just below the skin. For the most part, it is a direct continuation of the tendon of the palmaris longus, which expands onto the surface of the palm. Large and sheetlike on the proximal portion of the palm, the palmar aponeurosis develops radiating bands on the distal portion, which descend to each of the fingers. These tendinous bands attach to the skin superficially and to the metacarpal bones and flexor tendon sheaths deeply. The band to the thumb is thin and weak.

Because the descending bands of the palmar aponeurosis lie directly on top of the long flexor tendons of the fingers, a band and tendon of a finger together occasionally form a subtle elongated relief *on the palm* when that finger is flexed against resistance. This is most often seen in the middle finger and occasionally in the index and ring fingers.



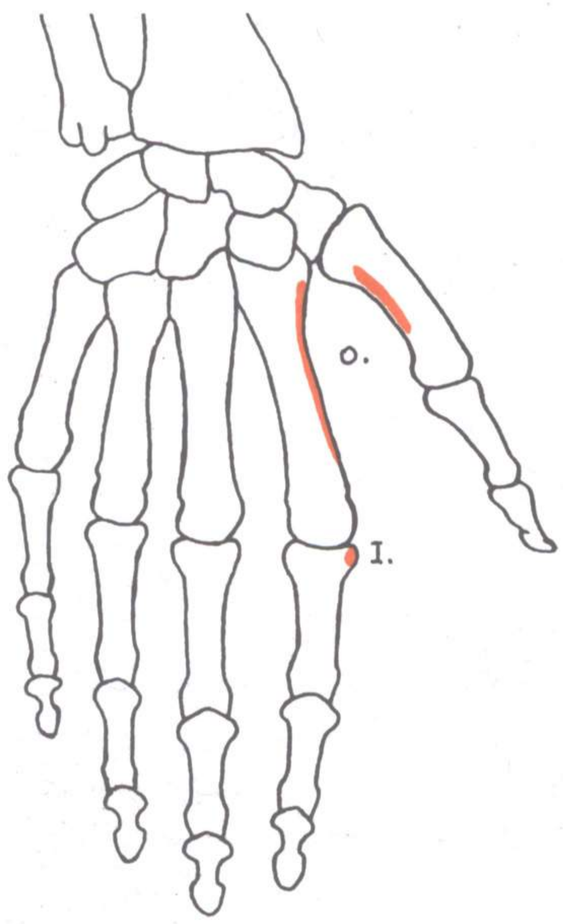
First Dorsal Interosseous (Abductor Indicis)

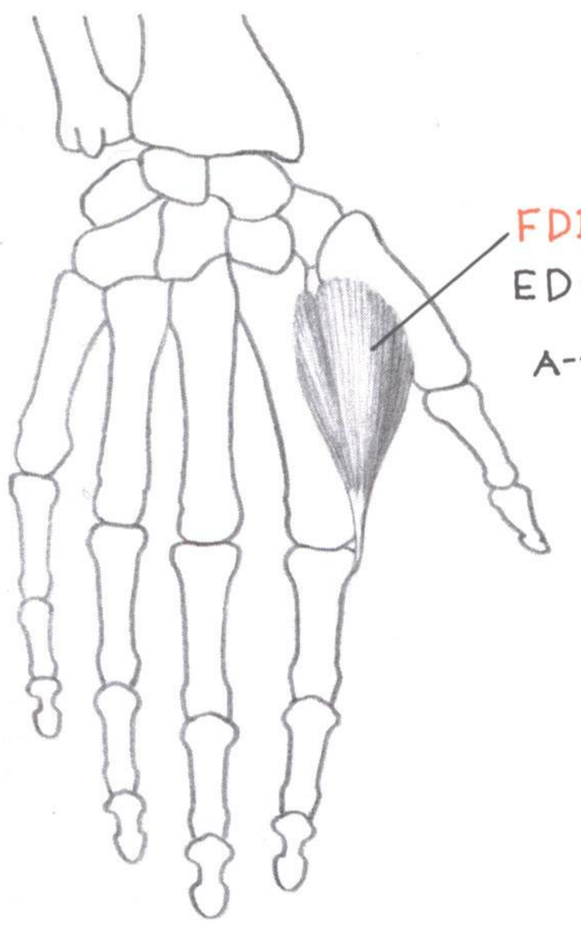
ORIGIN Proximal half of the ulnar side of the shaft of the metacarpal of the thumb and the proximal three-fourths of the radial side of the shaft of the metacarpal of the index finger (a V-shaped origin).

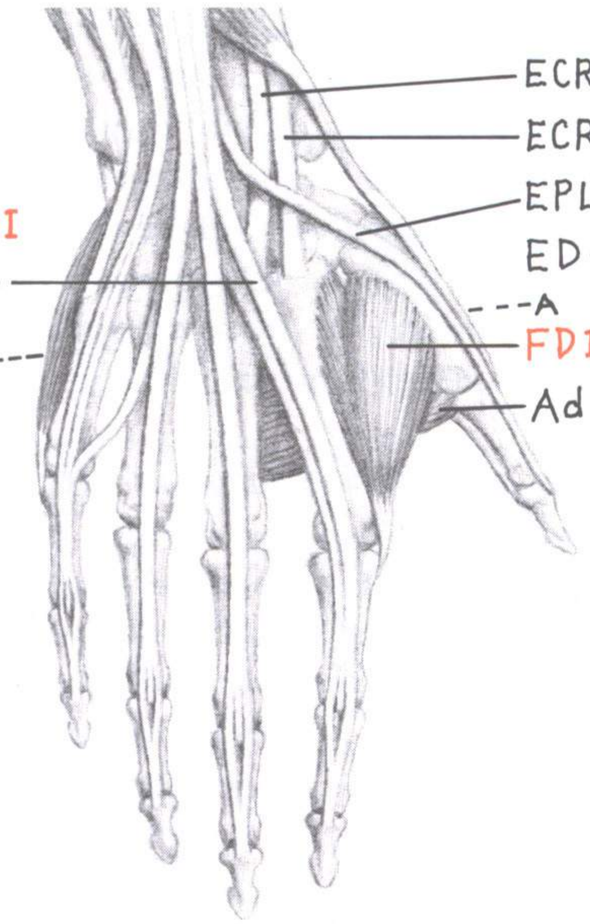
INSERTION Radial side of the base of the proximal phalanx of the index finger, with a small attachment to the dorsal extensor aponeurosis of the index finger.

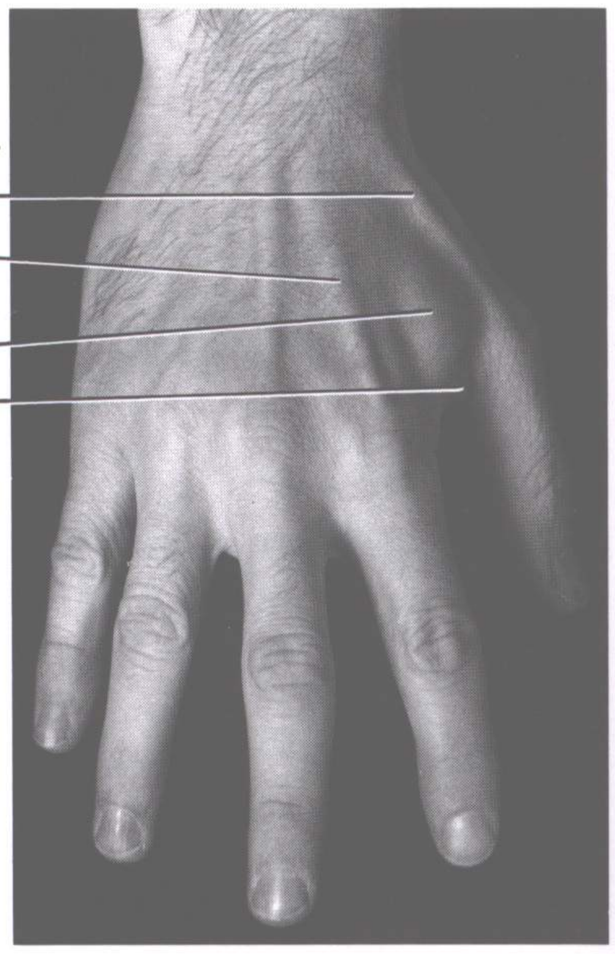
ACTION Adducts the index finger away from the middle finger; flexes its metacarpophalangeal joint; extends both interphalangeal joints via the dorsal extensor aponeurosis. It does not adduct the metacarpal of the thumb.

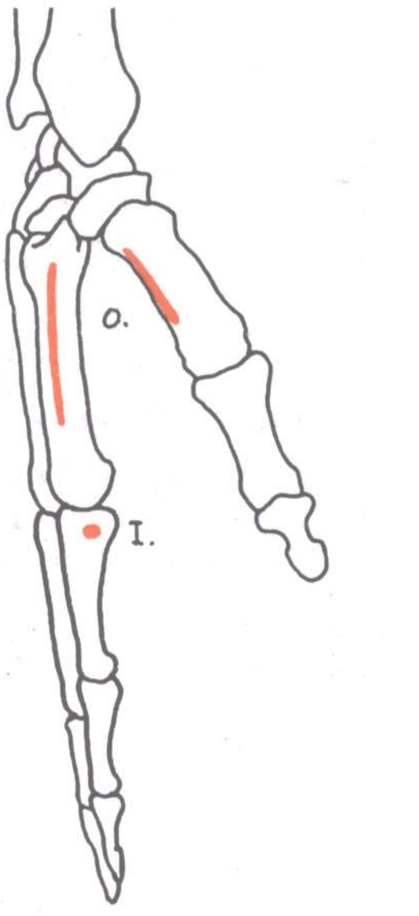
STRUCTURE The first dorsal interosseous is the largest of the four dorsal interosseous muscles and is the only one that creates surface form. It is located on the back of the hand in the V-shaped interval between the metacarpal bones of the thumb and index finger (the dorsal surfaces of these bones remain subcutaneous). Its two heads, each coming from a metacarpal, usually show up as a single bulging form that is either teardrop-shaped or oval. A slight separation between the heads may occasionally show at the proximal end of the belly when the muscle is tensed. The muscle belly, and therefore its bulging form, tapers into a tendon before reaching the level of the metacarpophalangeal joint.

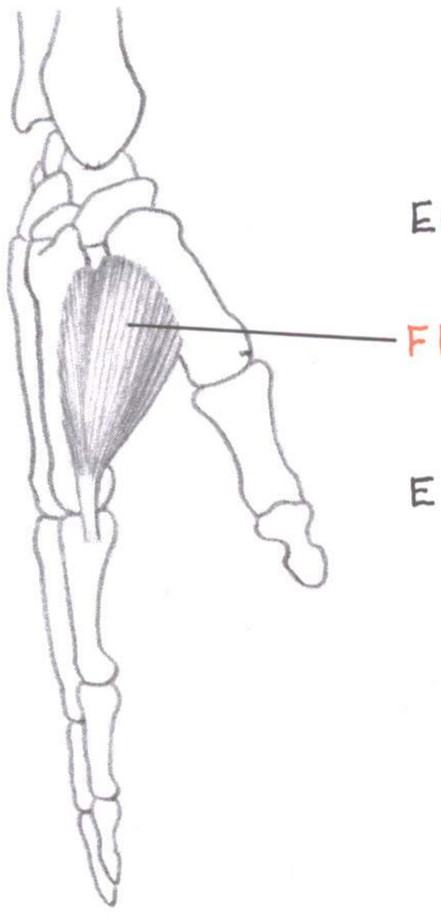


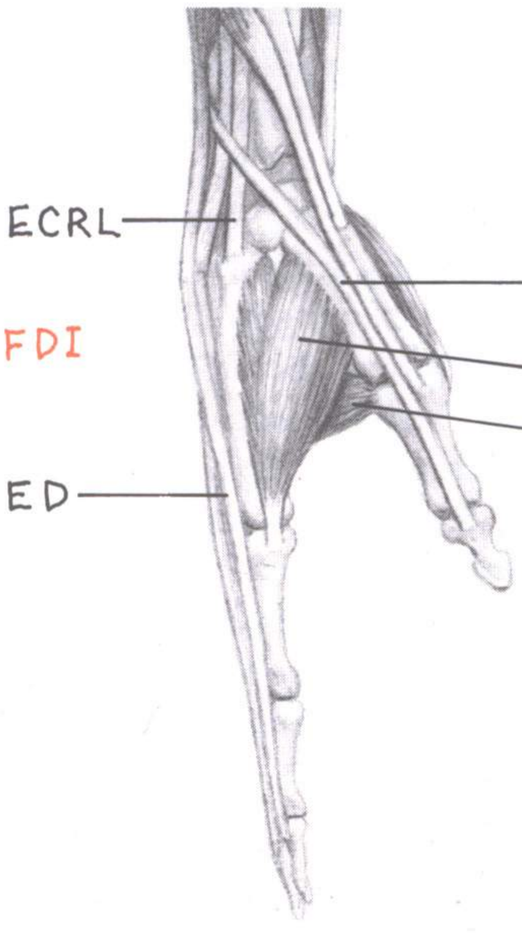


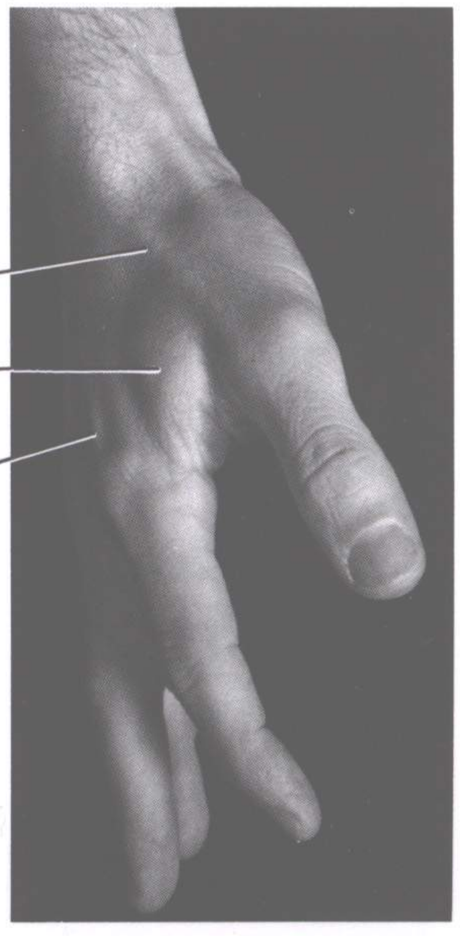




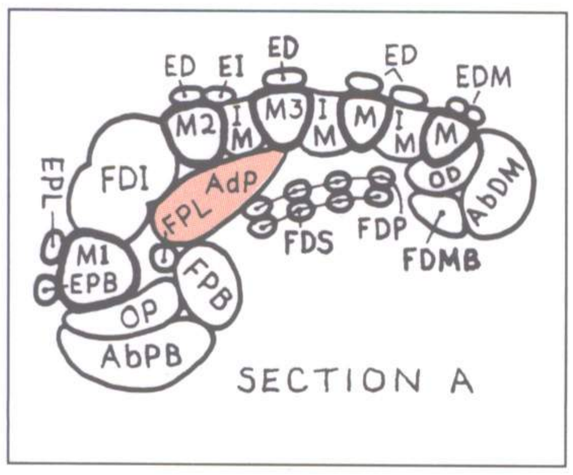








AbPB *Abductor pollicis brevis* **AdP** *Adductor pollicis* **ECRB** *Extensor carpi radialis brevis*
ECRL *Extensor carpi radialis longus* **ED** *Extensor digitorum* **EPL** *Extensor pollicis longus*
FDI *First dorsal interosseous* **FDP** *Flexor digitorum profundus* **FDS** *Flexor digitorum superficialis*



Adductor Pollicis—Transverse Head

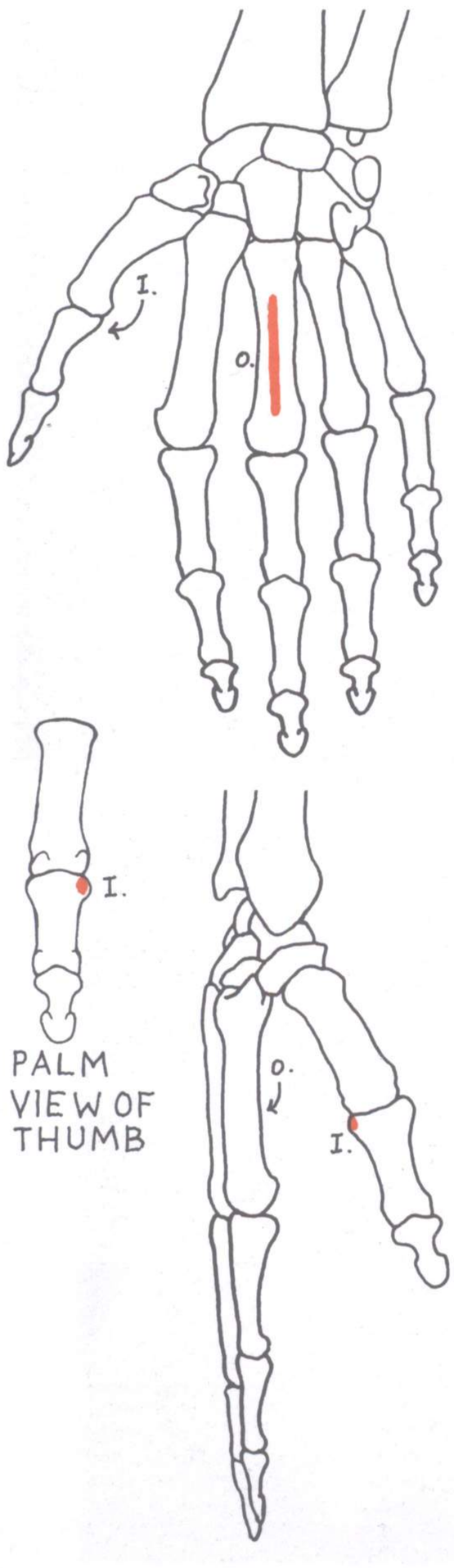
ORIGIN Distal two-thirds of the palmar surface of the metacarpal of the middle finger.

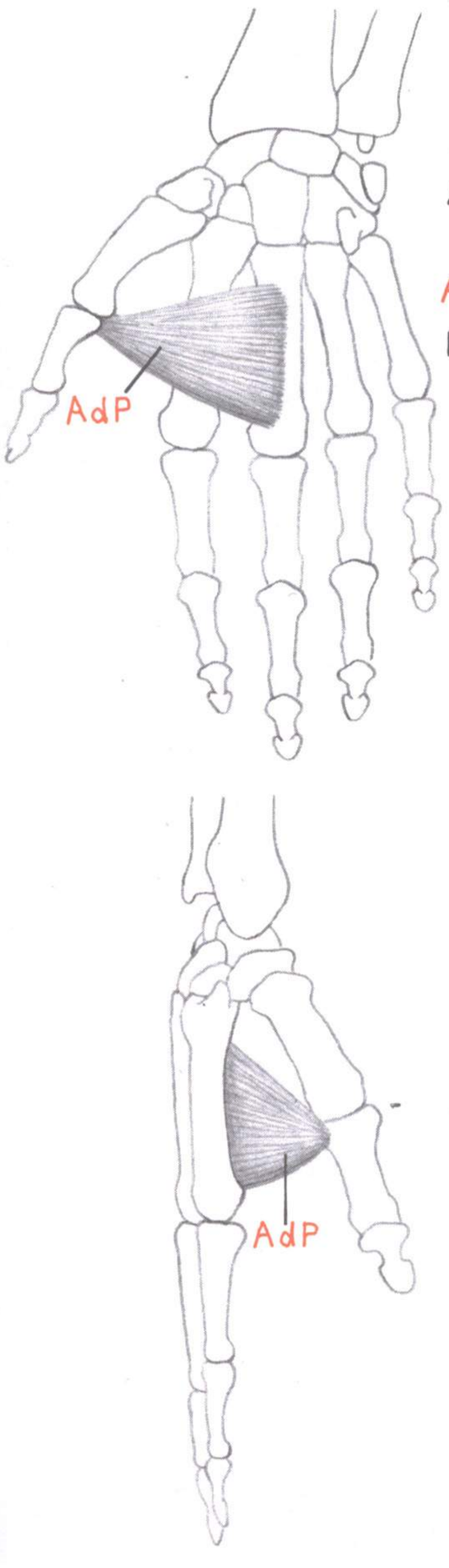
INSERTION Ulnar side of the base of the proximal phalanx of the thumb.

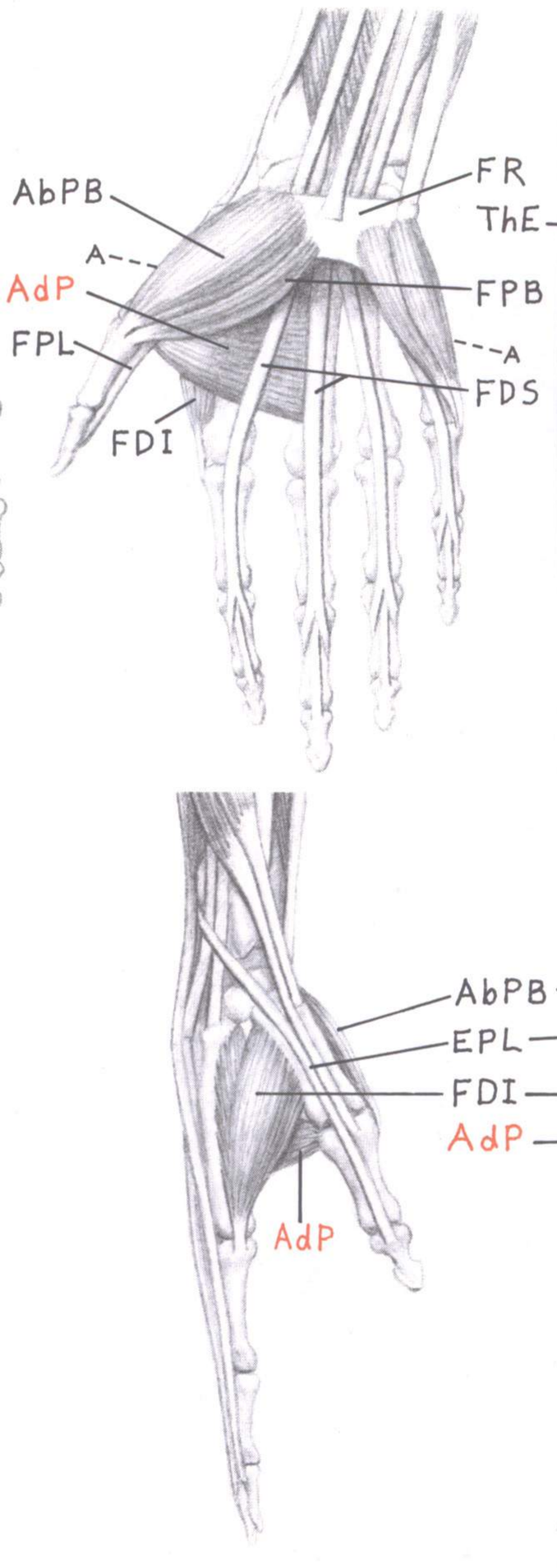
ACTION Adducts and flexes the thumb at the carpometacarpal joint; flexes its proximal phalanx at the metacarpophalangeal joint.

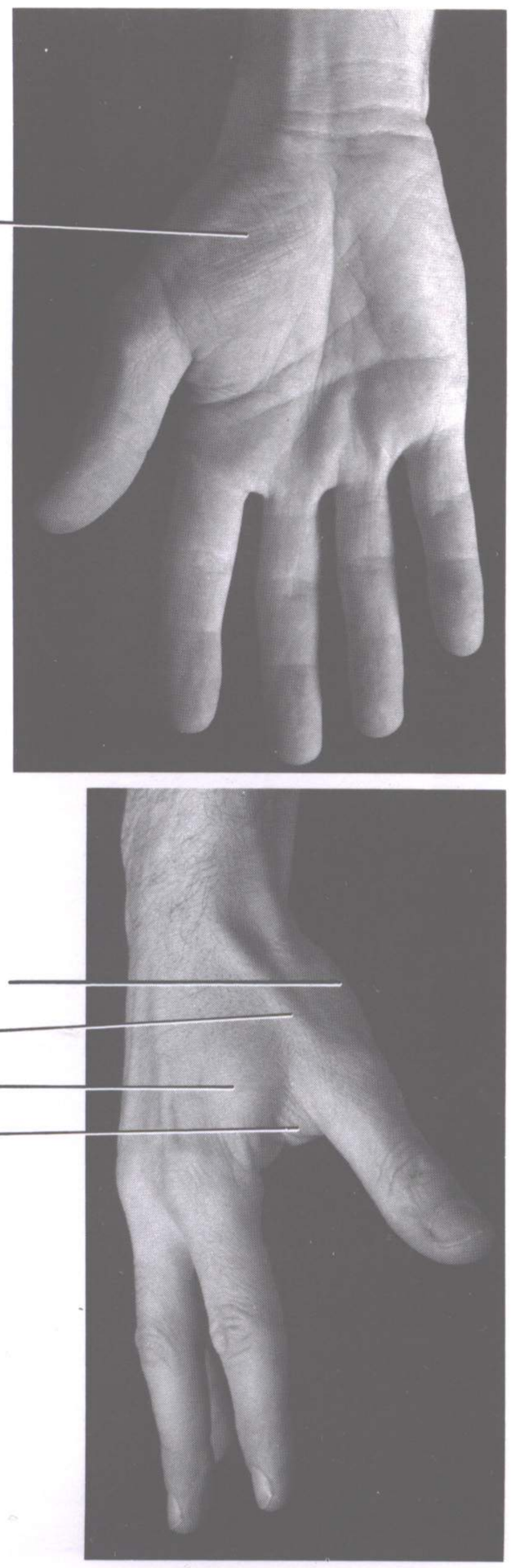
STRUCTURE The flat, triangular, **transverse head** of the adductor pollicis passes from the middle of the palm to the thumb. Barely noticeable in life, its palmar surface and distal edge are covered by a layer of loose skin. A small portion, however, can be seen on the dorsal side of the hand between the first dorsal interosseous and the base of the proximal phalanx of the thumb. The tendon of insertion of the adductor pollicis contains the ulnar sesamoid bone of the metacarpophalangeal joint of the thumb.

The more proximal **oblique head** of the adductor pollicis lies deep to the thenar eminence in the palm.

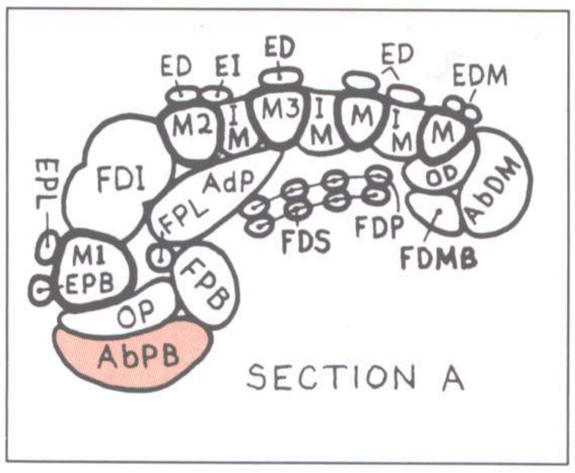








FPB *Flexor pollicis brevis* **FPL** *Flexor pollicis longus* **FR** *Flexor retinaculum* **IM** *Interosseous muscle*
M *Metacarpal* **ThE** *Thenar eminence*



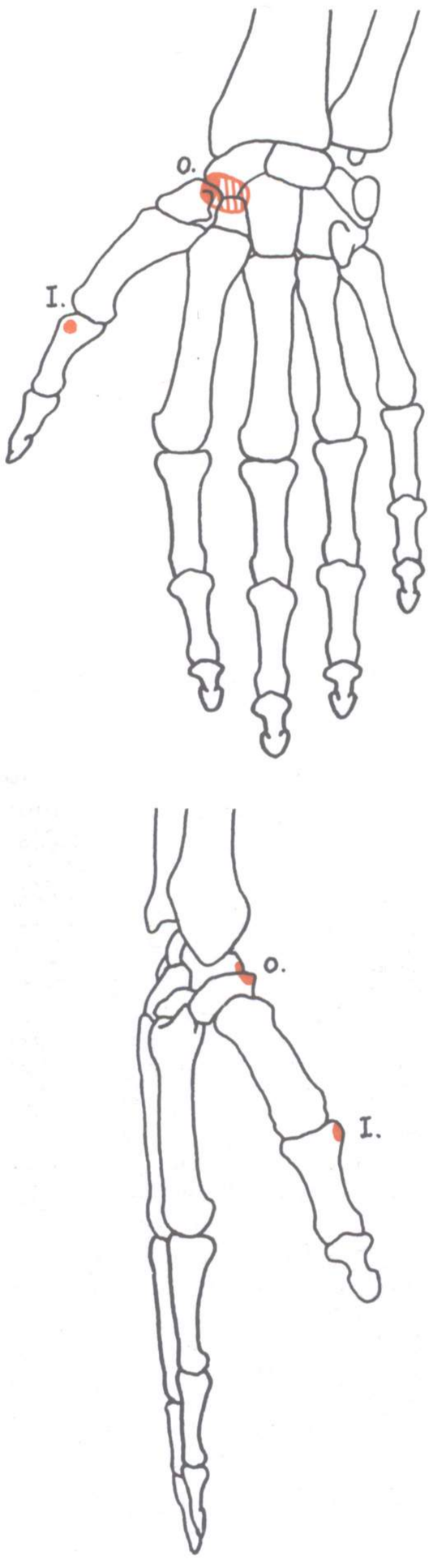
Abductor Pollicis Brevis

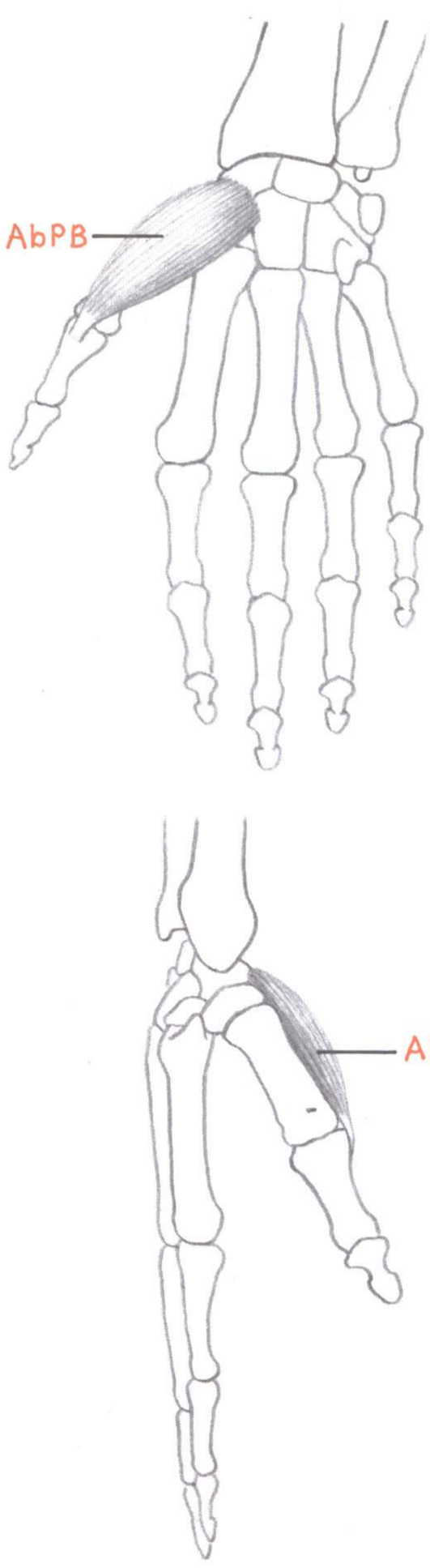
ORIGIN Anterior surface of the lateral half of the flexor retinaculum and the adjacent palmar surfaces of the trapezium (its tubercle) and scaphoid. It also frequently originates in part from the tendon of the abductor pollicis longus and occasionally from the tendon of the palmaris longus.

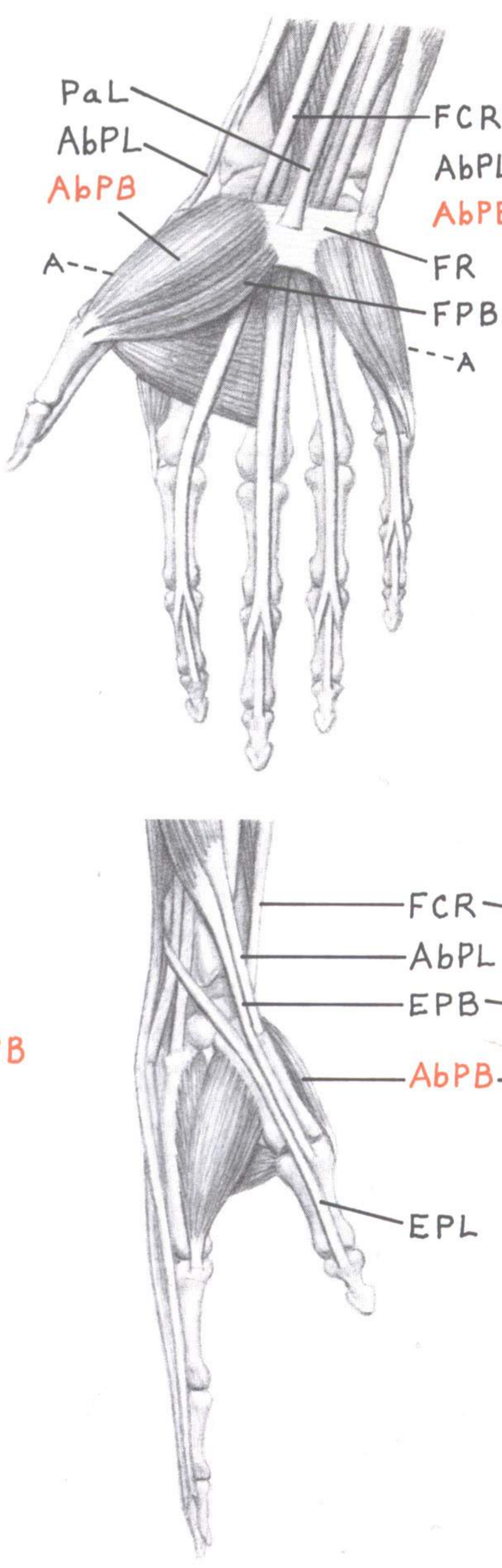
INSERTION Radial side of the base of the proximal phalanx of the thumb and into the tendon of the extensor pollicis longus.

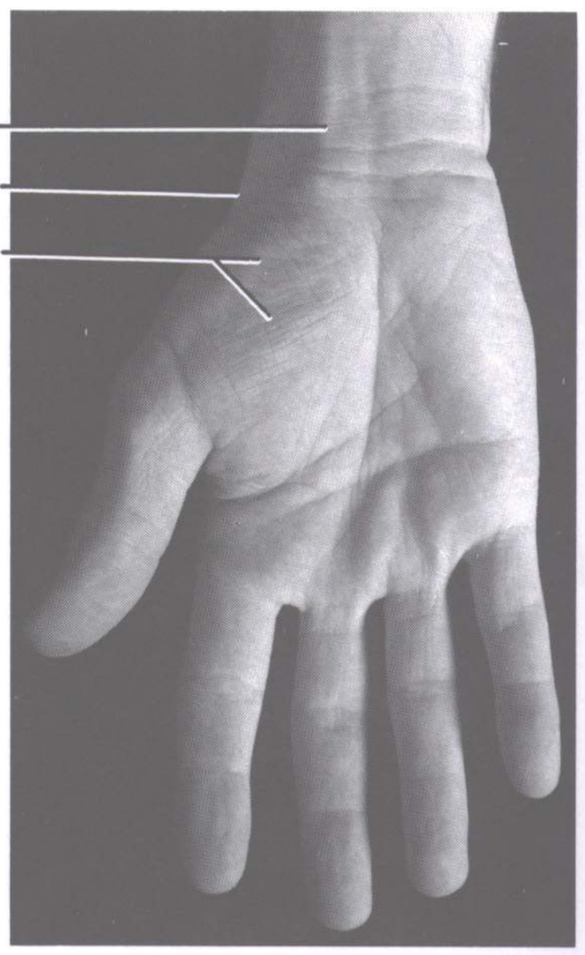
ACTION Abducts the thumb away from (anterior to) the palm (on a plane perpendicular to the palm) at the carpometacarpal joint; it simultaneously rotates the thumb medially at the same joint (a saddle joint). It assists in flexing the metacarpophalangeal joint of the thumb, and by its attachment into the tendon of the extensor pollicis longus, assists in extending the interphalangeal joint of the thumb.

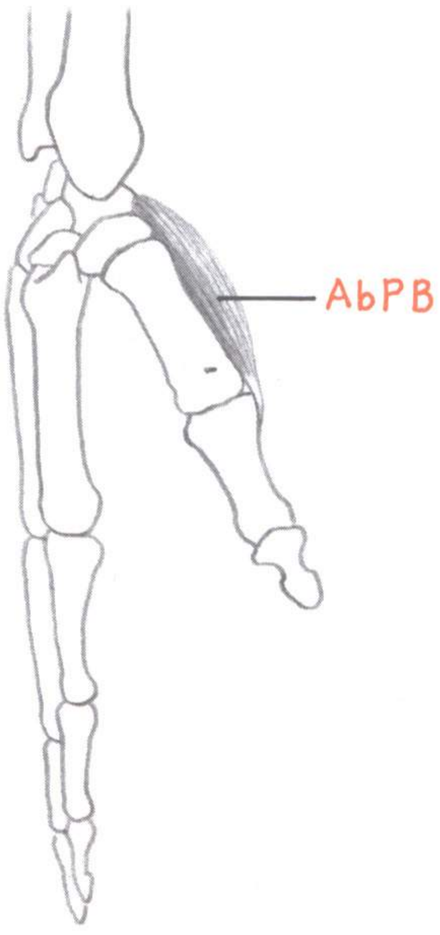
STRUCTURE Largest of the thenar muscles, the abductor pollicis brevis is a flat, elongated, triangular muscle. When the thumb is abducted, the form of this muscle divides longitudinally into two narrow parallel forms: a more prominent *lateral form* that originates from the carpal bones and tendon of insertion of the abductor pollicis longus and a *medial form* that originates from the flexor retinaculum. These forms are produced by the descent of tendinous slips from the tendons of the abductor pollicis longus and palmaris longus onto the surface of the belly of the abductor pollicis brevis. When the thumb is abducted, numerous thin, transverse skin wrinkles develop across the surface of this muscle.

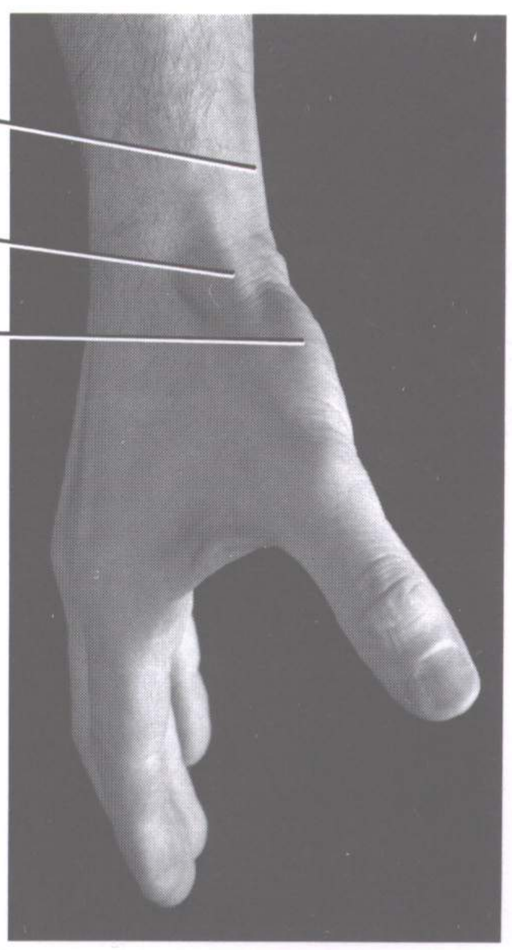




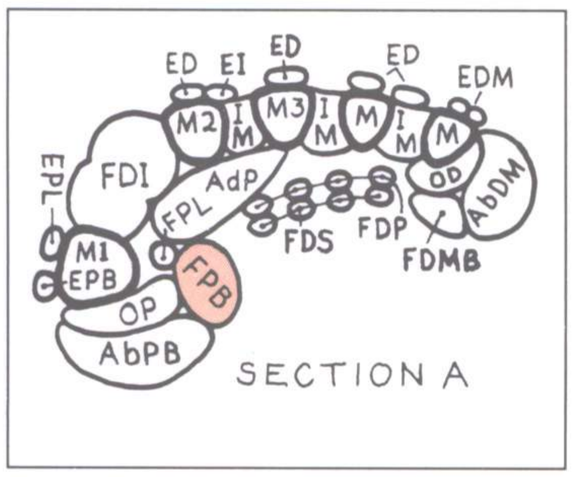








AbPB *Abductor pollicis brevis* **AbPL** *Abductor pollicis longus* **AdP** *Adductor pollicis*
EPB *Extensor pollicis brevis* **EPL** *Extensor pollicis longus* **FCR** *Flexor carpi radialis*
FDS *Flexor digitorum superficialis* **FPB** *Flexor pollicis brevis* **FPL** *Flexor pollicis longus*



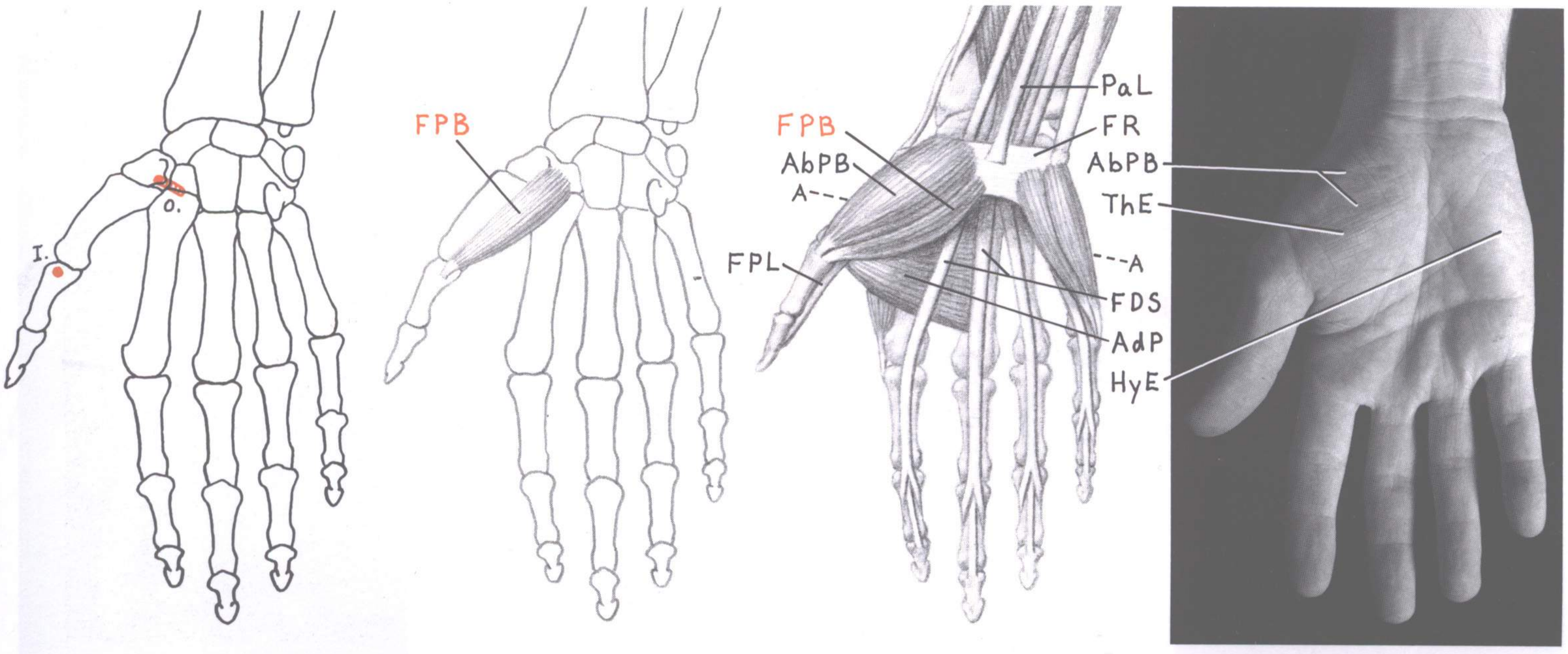
Flexor Pollicis Brevis

ORIGIN Palmar surface of the trapezium (an area medial and distal to the origin of the abductor pollicis brevis) and the distal border of the lateral half of the flexor retinaculum.

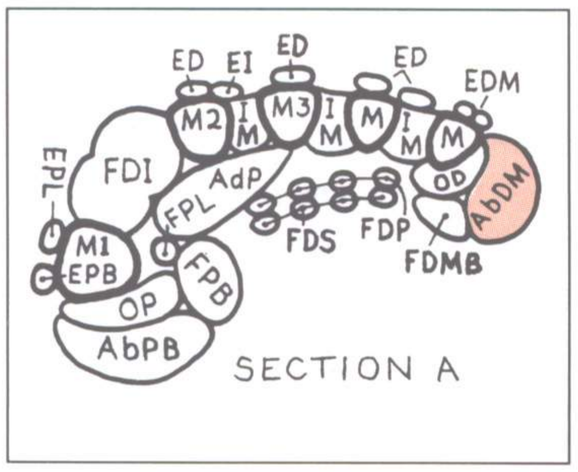
INSERTION Radial and part of the palmar side of the base of the proximal phalanx of the thumb.

ACTION Flexes the proximal phalanx of the thumb; assists in opposition of the thumb against the other fingers. It also assists in medial rotation of the metacarpal of the thumb at the carpometacarpal joint.

STRUCTURE The flexor pollicis brevis is a small, narrow muscle, located medial to the abductor pollicis brevis, which contributes to the form of the thenar eminence. Although it is for the most part subcutaneous with its medial edge at the medial border of the thenar eminence, its actual form is usually obscured by a layer of palmar fat. Its tendon of insertion contains the radial sesamoid bone of the metacarpophalangeal joint of the thumb.



FR *Flexor retinaculum* **HyE** *Hypothenar eminence* **M** *Metacarpal* **OP** *Opponens pollicis*
PaL *Palmaris longus* **ThE** *Thenar eminence*



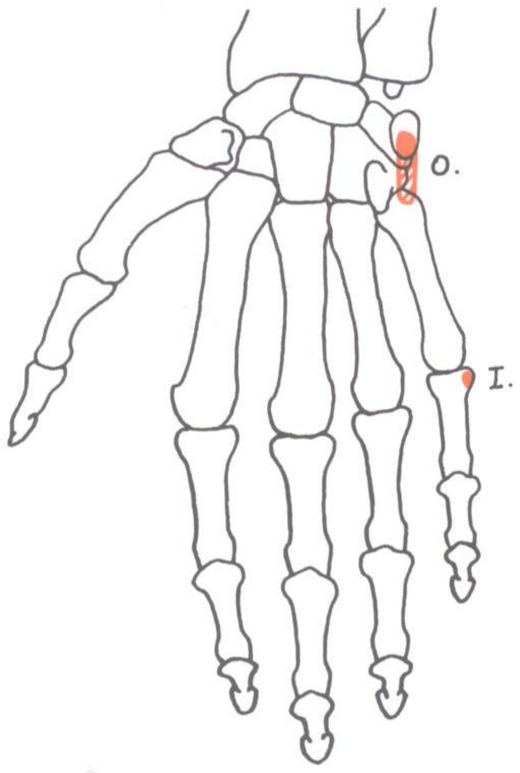
Abductor Digiti Minimi

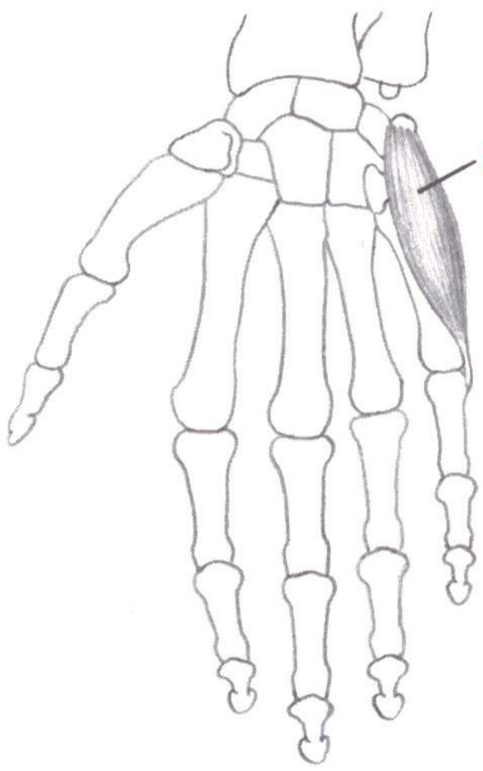
ORIGIN Tip of the pisiform bone and from the anterior surface of the ligament connecting the pisiform bone to the base of the fifth metacarpal.

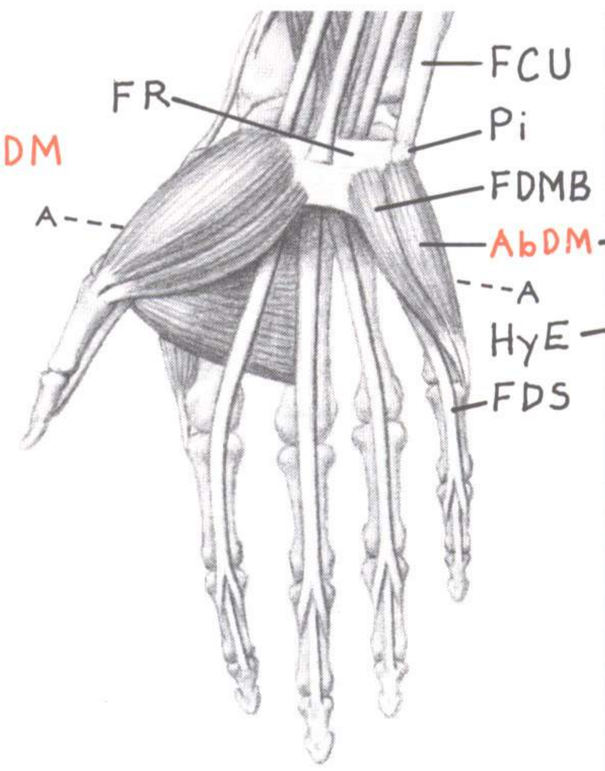
INSERTION Ulnar side of the base of the proximal phalanx of the little finger (in common with the flexor digiti minimi brevis) and ulnar border of the dorsal extensor aponeurosis of the tendon of the extensor digiti minimi (on the back of the proximal phalanx of the little finger).

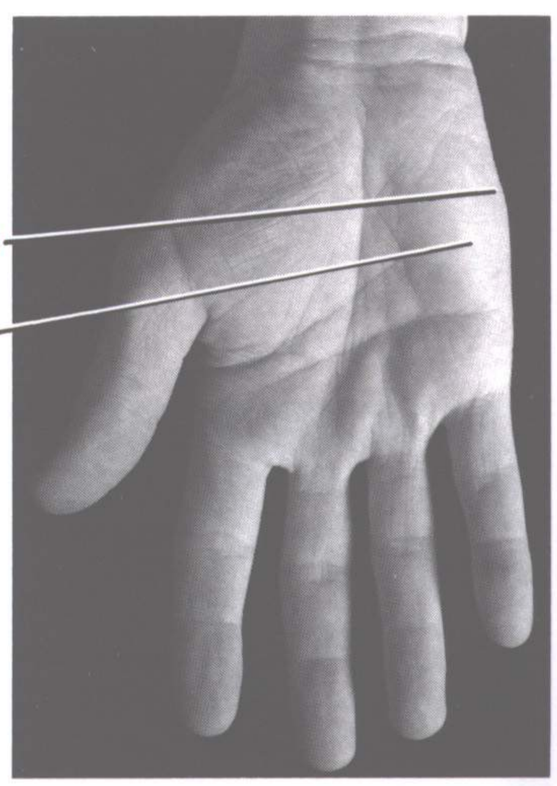
ACTION Abducts and flexes the little finger at the metacarpophalangeal joint; extends the interphalangeal joints (via its insertion into the dorsal extensor aponeurosis).

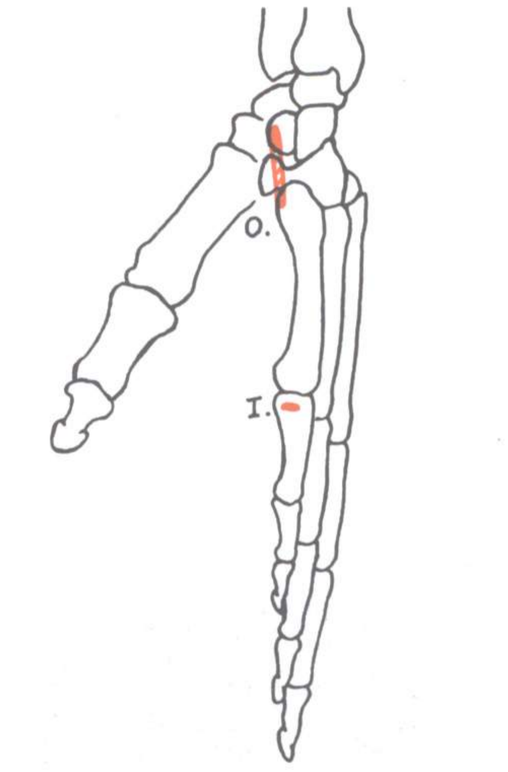
STRUCTURE The abductor digiti minimi is the largest of the hypothenar muscles. It wraps around the ulnar side of the hand up to the *side* of the metacarpal of the little finger; therefore, it can be seen from the back view of the hand.

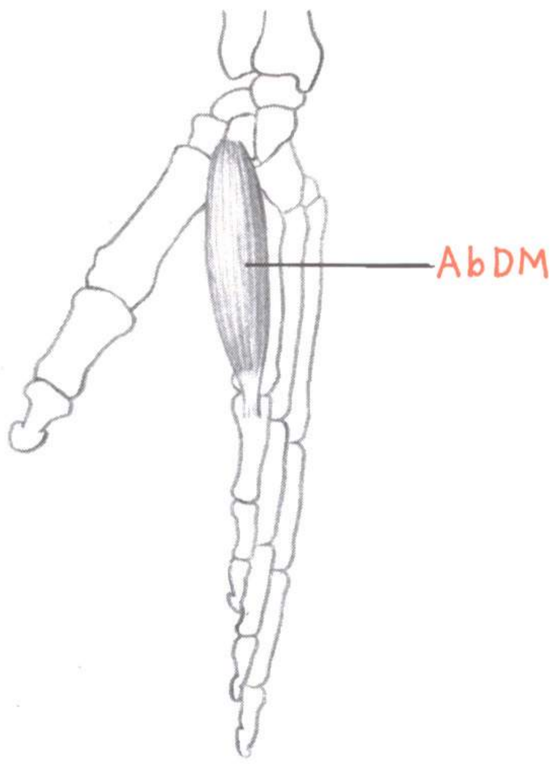


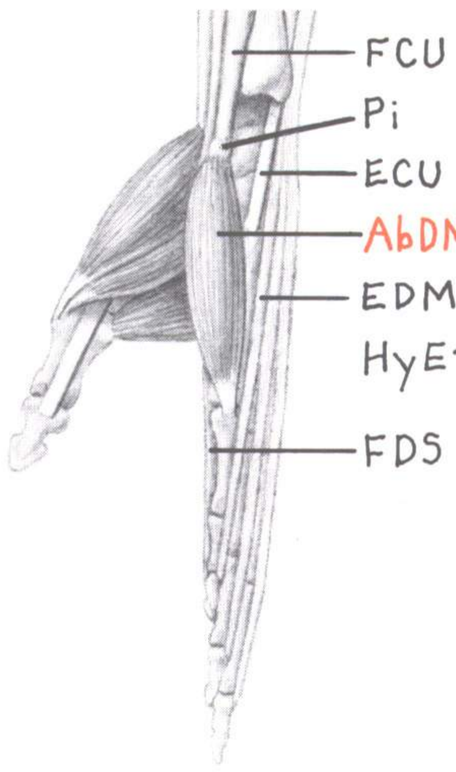


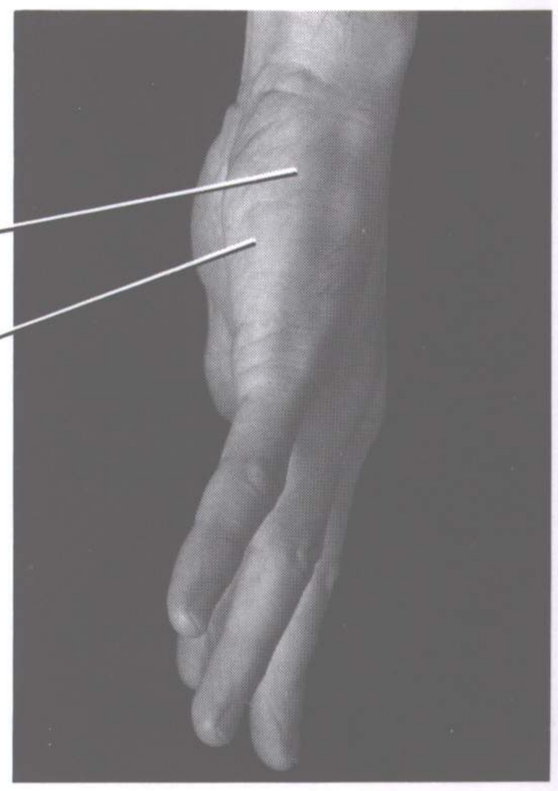


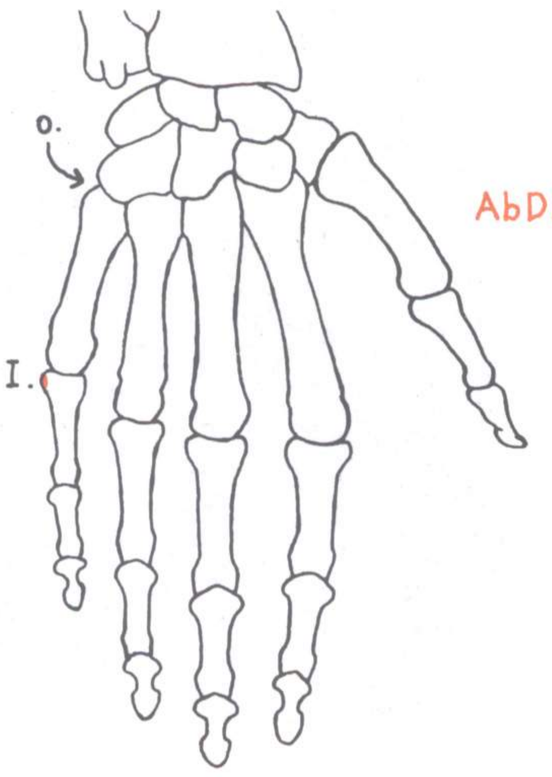


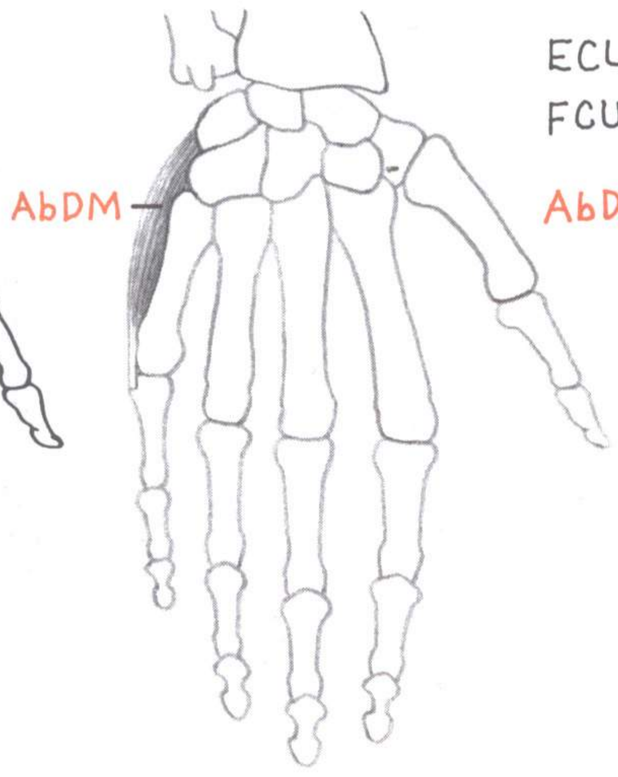


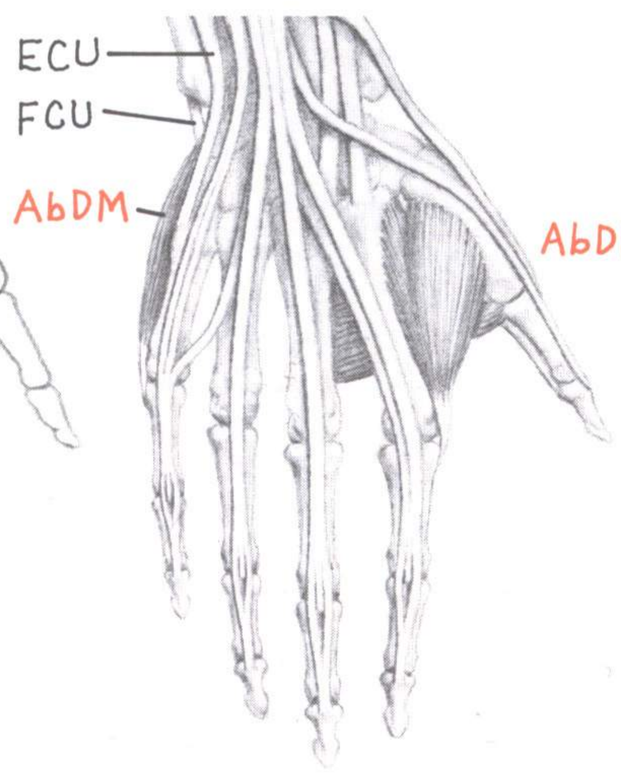




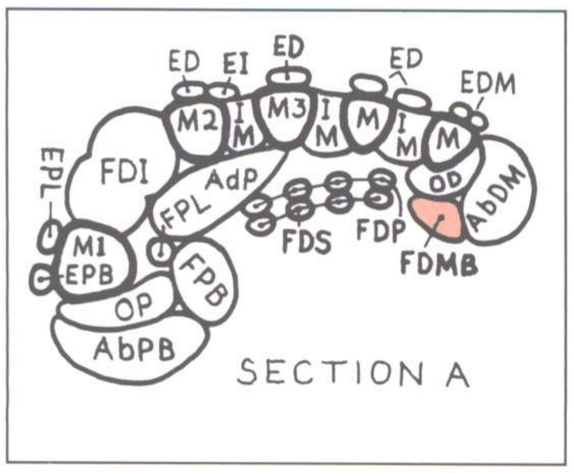








AbDM *Abductor digiti minimi* **ECU** *Extensor carpi ulnaris* **EDM** *Extensor digiti minimi*
FCU *Flexor carpi ulnaris* **FDMB** *Flexor digiti minimi brevis* **FDS** *Flexor digitorum superficialis*



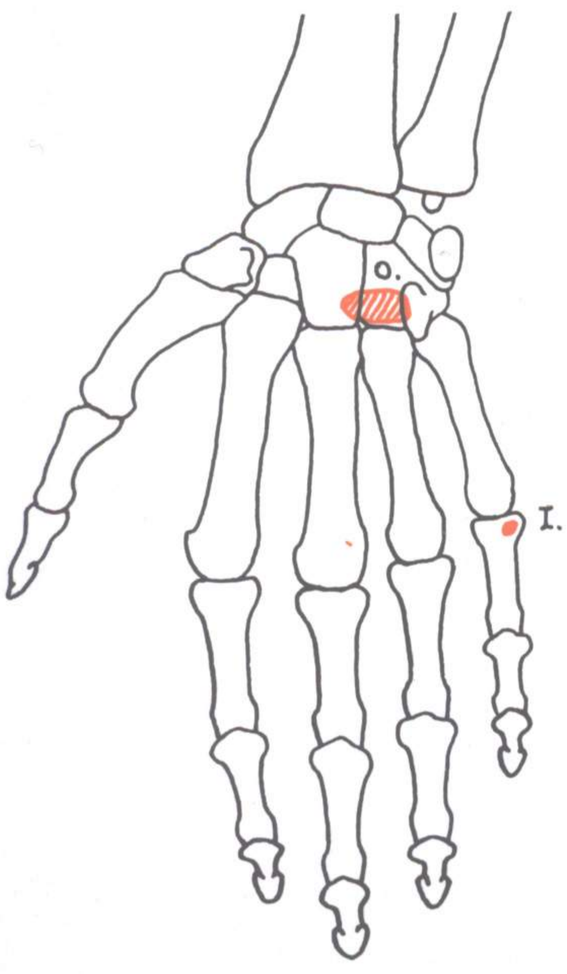
Flexor Digiti Minimi Brevis

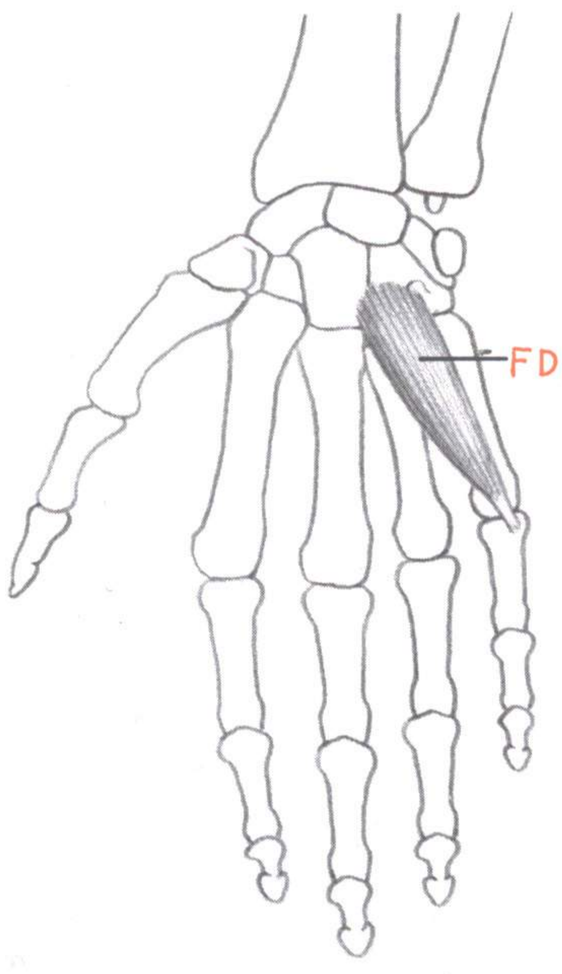
ORIGIN Medial surface of the hook of the hamate bone and anterior surface of the medial half of the flexor retinaculum.

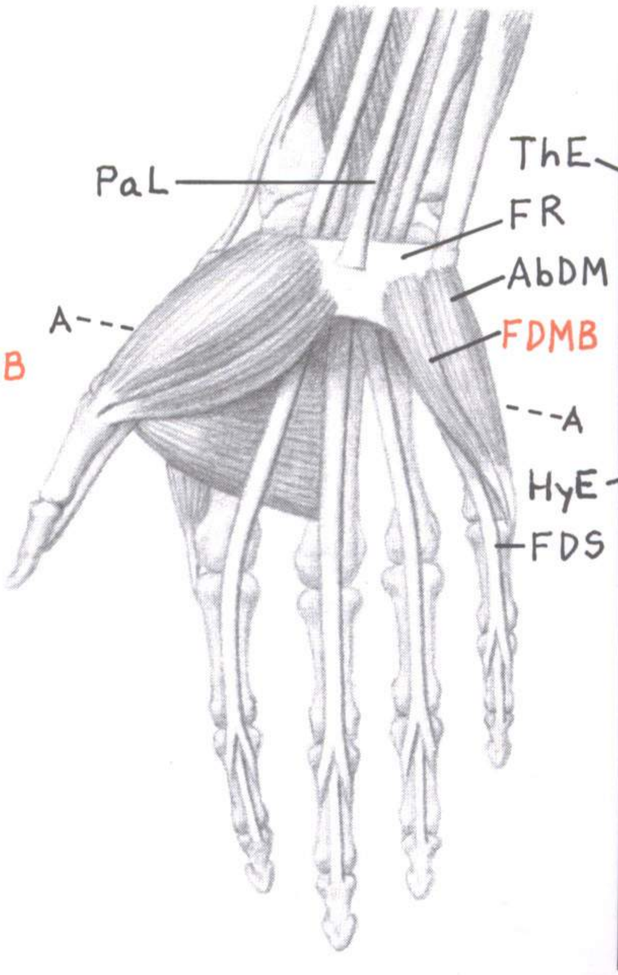
INSERTION Ulnar and part of the palmar side of the base of the proximal phalanx of the little finger (in common with the abductor digiti minimi).

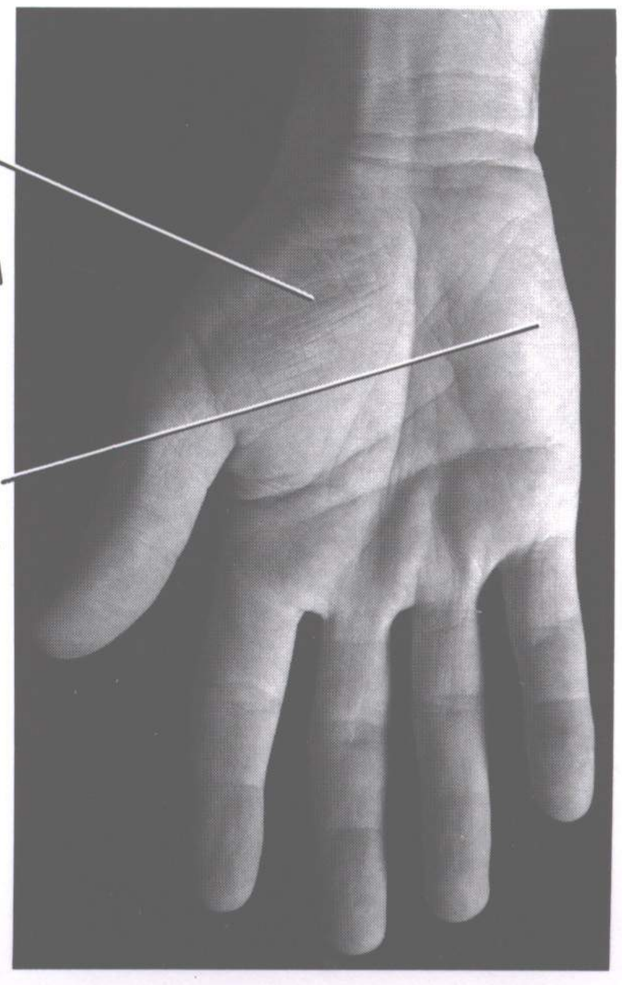
ACTION Flexes the proximal phalanx of the little finger; assists in abducting it.

STRUCTURE The flexor digiti minimi brevis is a very narrow muscle located between the abductor digiti minimi and opponens digiti minimi. Contributing to the volume of the hypothenar eminence, its actual form is obscured by a layer of palmar fat.



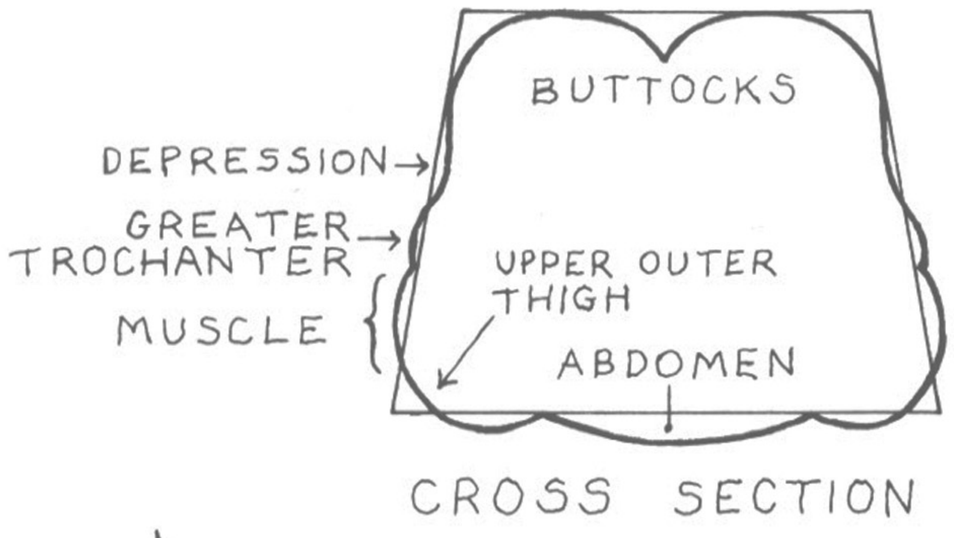




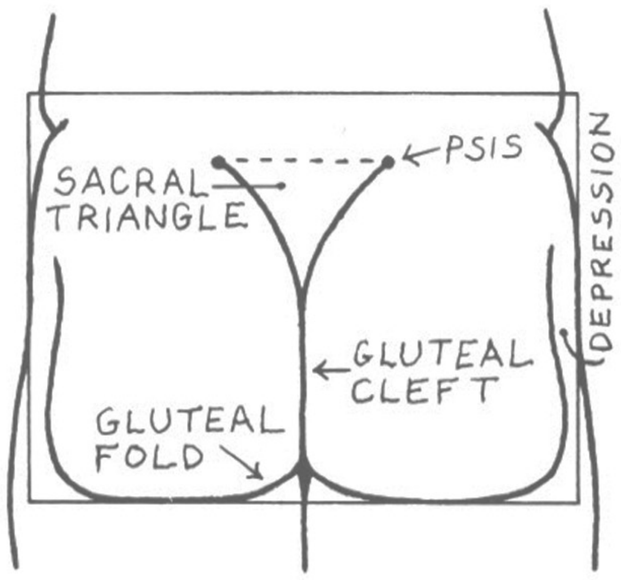


FR *Flexor retinaculum* **HyE** *Hypothenar eminence* **M** *Metacarpal* **OD** *Opponens digiti minimi*
PaL *Palmaris longus* **Pi** *Pisiform bone* **ThE** *Thenar eminence*

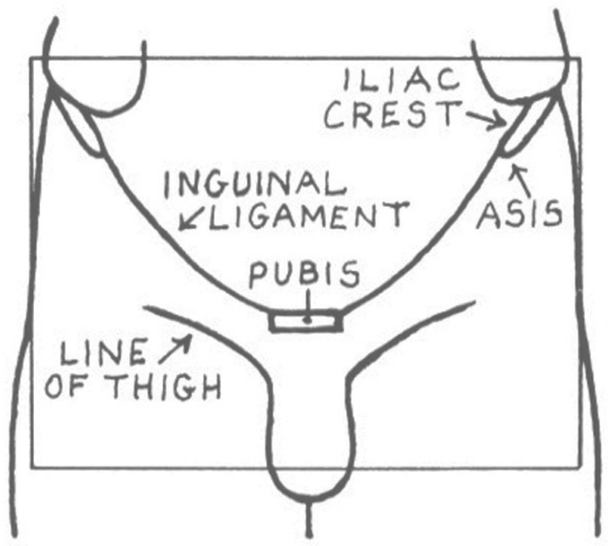
The Hip Muscles



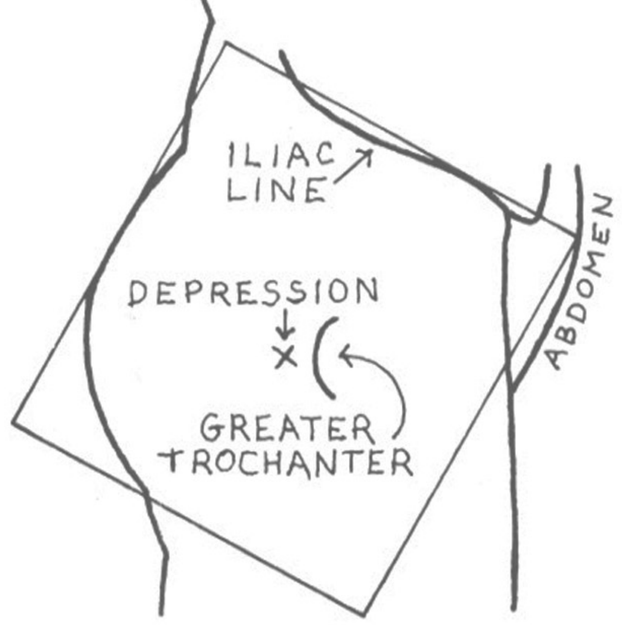
CROSS SECTION



BACK VIEW



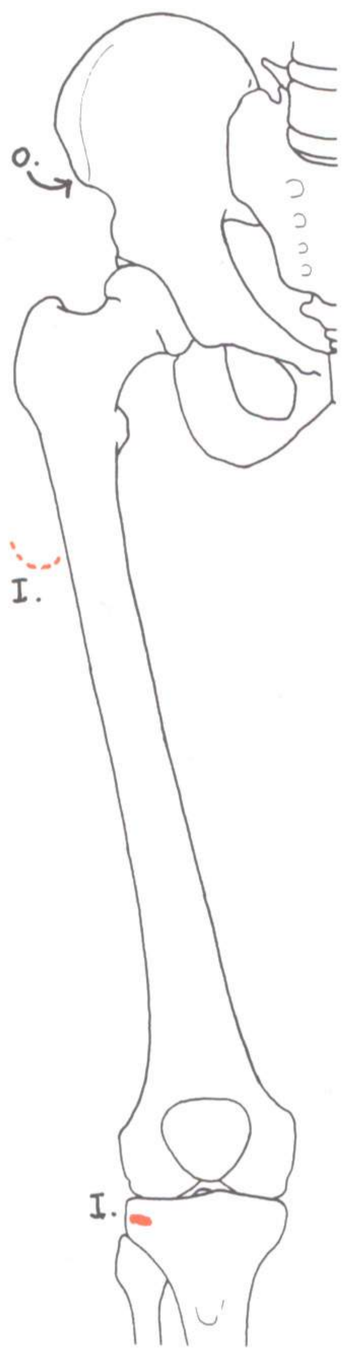
FRONT VIEW

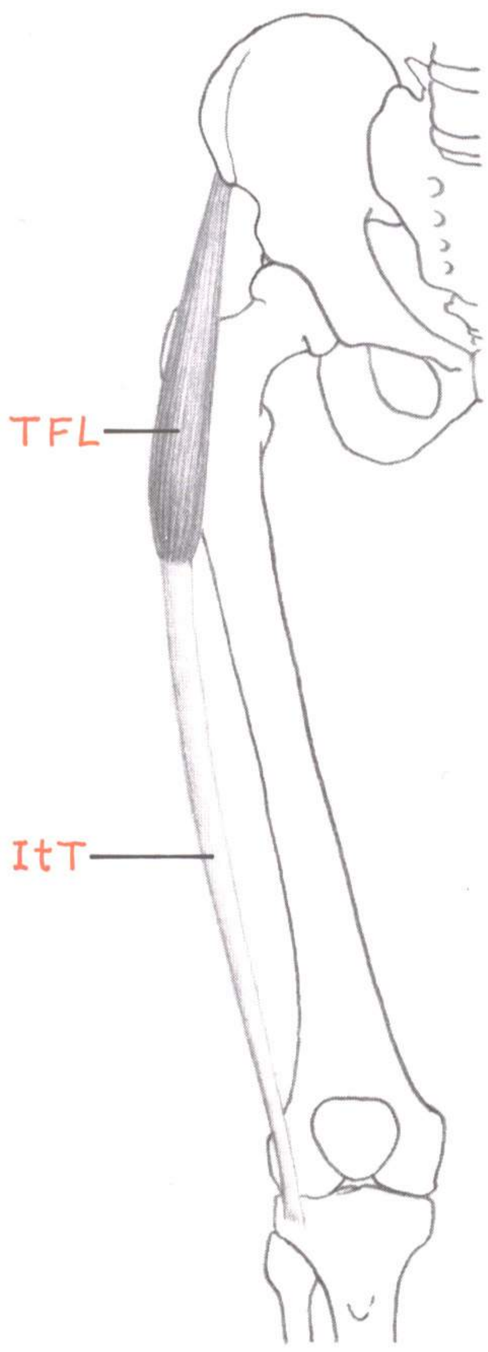


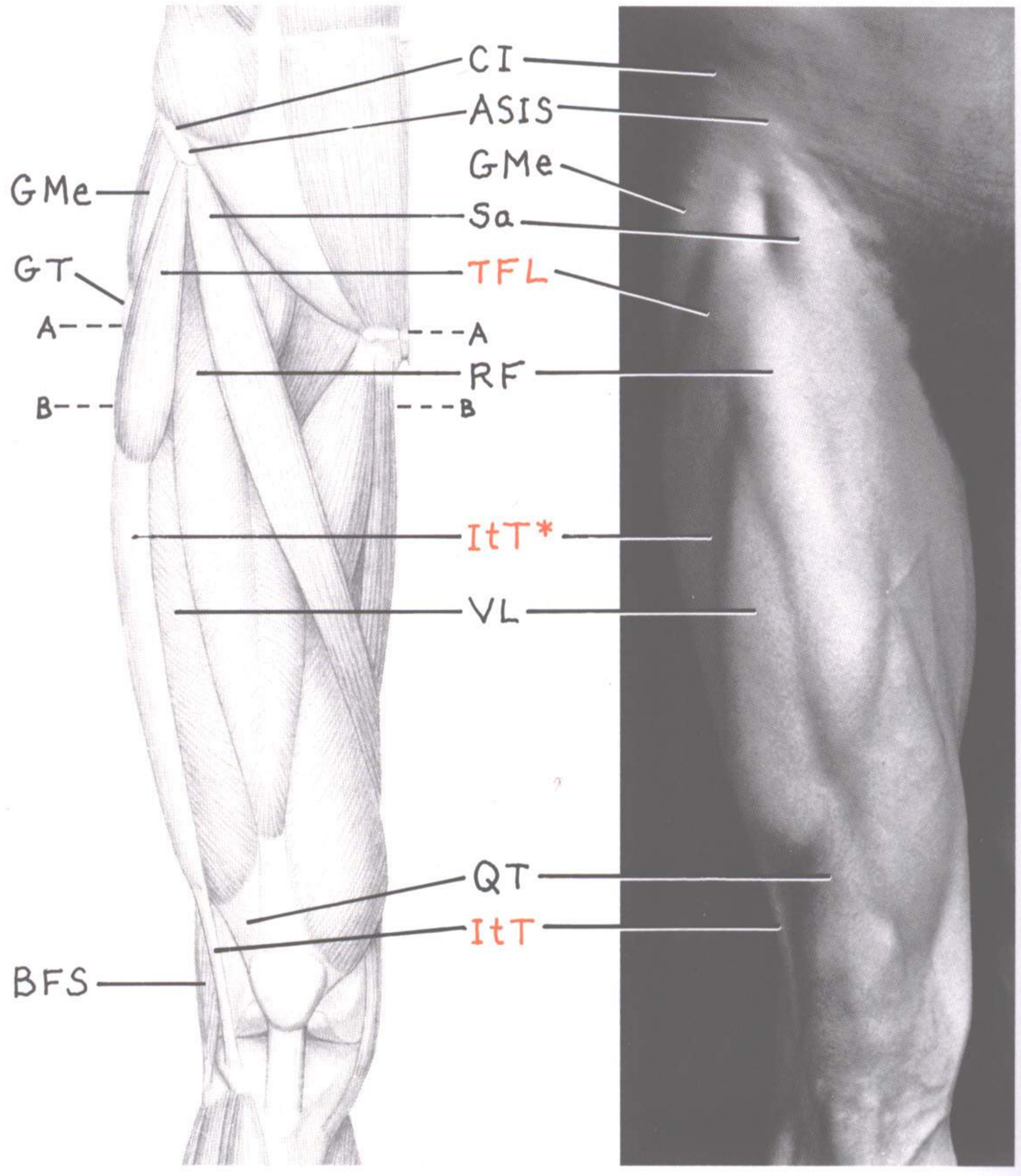
SIDE VIEW

The Hip Muscles

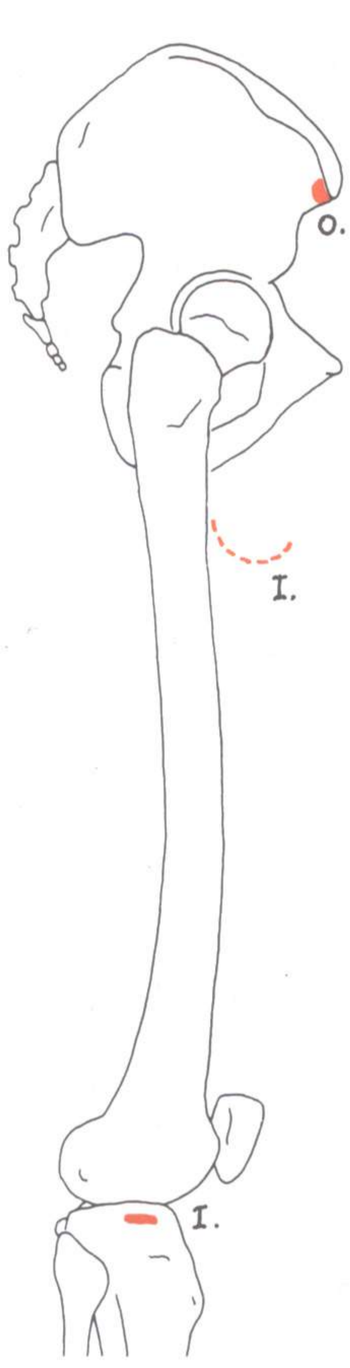
The *HIP* region, consisting of the pelvis and its surrounding musculature, forms a somewhat boxlike volume whose upper end is tipped forward. It is narrow posteriorly and wide anteriorly; its side planes converge toward the back. The front and back planes of this box are roughly parallel—the back plane is formed by the sacrum, the overlying spinal muscles, and the posterior portion of the gluteus maximus, while the front plane is formed primarily by the lower portion of the rectus abdominis. The gluteus medius and gluteus maximus form the side of the box, at the center of which lies the greater trochanter. The rectus abdominis holds back the abdominal contents, and this region has a soft and rounded quality in relation to the muscular sides and planar back.

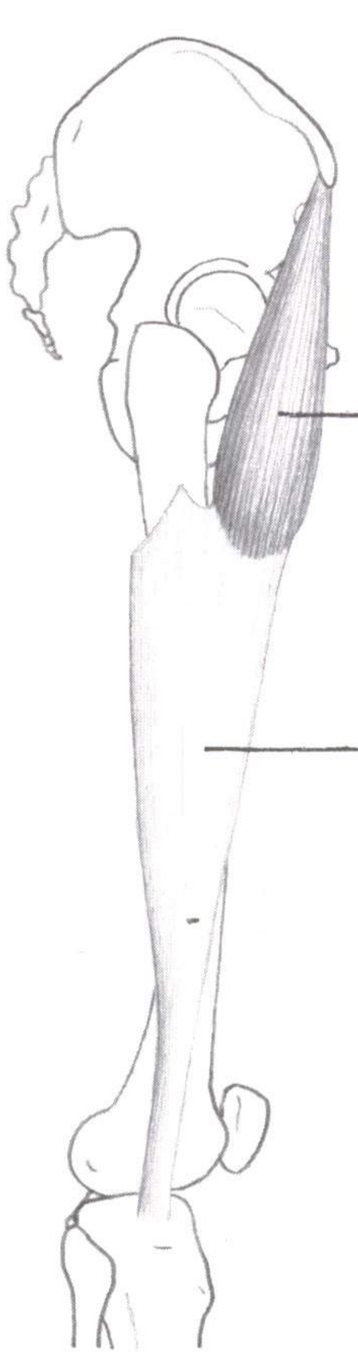


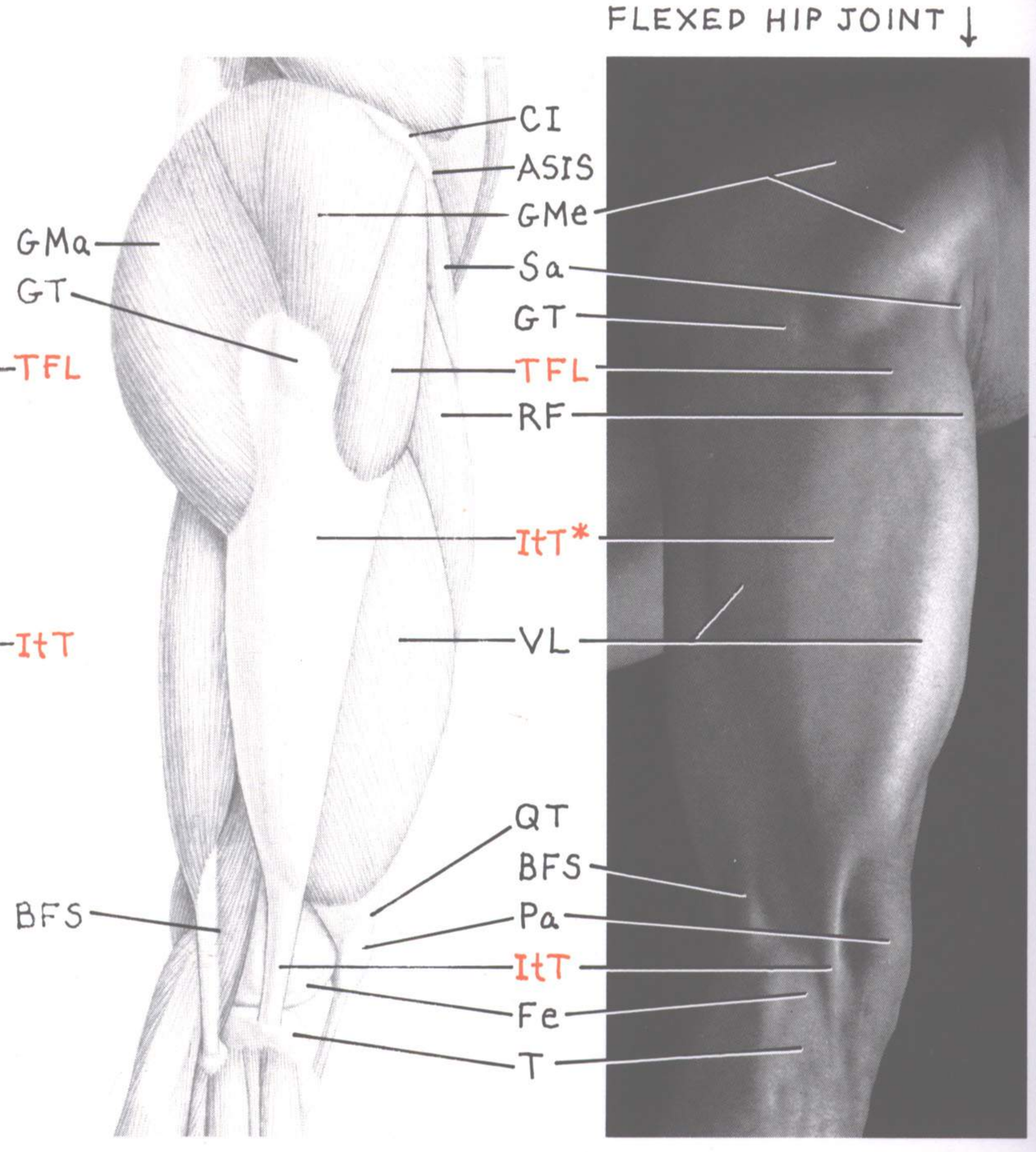




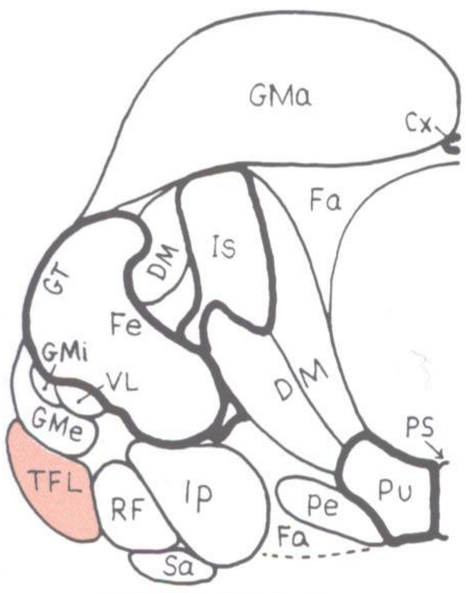
FLEXED HIP JOINT ↓



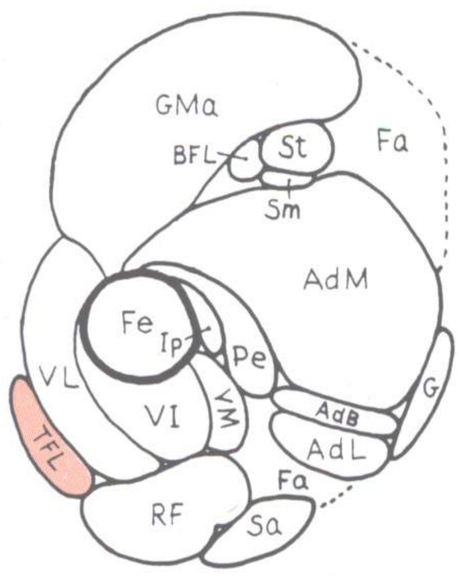




ASIS *Anterior superior iliac spine* **BFS** *Biceps femoris—short head* **CI** *Crest of ilium* **Fe** *Femur*
GMa *Gluteus maximus* **GMe** *Gluteus medius* **GT** *Greater trochanter* **ItT** *Iliotibial tract* **Pa** *Patella*
QT *Quadriceps tendon* **RF** *Rectus femoris* **Sa** *Sartorius* **T** *Tibia* **TFL** *Tensor fascia lata*
VL *Vastus lateralis* * *On vastus lateralis*



SECTION A



SECTION B

Tensor Fascia Lata

ORIGIN Anterior part of the outer lip of the iliac crest and a small area of the adjacent outer surface of the ilium immediately posterior to the anterior superior iliac spine.

INSERTION The upper portion the iliotibial tract, which in turn inserts into the lateral condyle of the tibia.

ACTION Flexes, abducts, and medially rotates the thigh. The tensor fascia lata pulling on the iliotibial tract stabilizes the outside of the knee joint.

STRUCTURE The tensor fascia lata is a short, thick, teardrop-shaped muscle located on the outer front corner of the pelvis. Its form begins at the front point of the hip and ends where the muscle attaches into the iliotibial band, at a level just below and in front of the greater trochanter of the femur (near the level of the bottom of the buttocks). Its wider, flattened, distal end lies *on top of* the form of the vastus lateralis.

In the standing position, the belly becomes stretched into an elongated oval shape (somewhat pointed inferiorly), but as the thigh is flexed, it changes into its characteristic teardrop shape. As the thigh continues flexing, the distal end widens (front to back). At full hip flexion, the belly is crossed transversely by a deep skin fold.

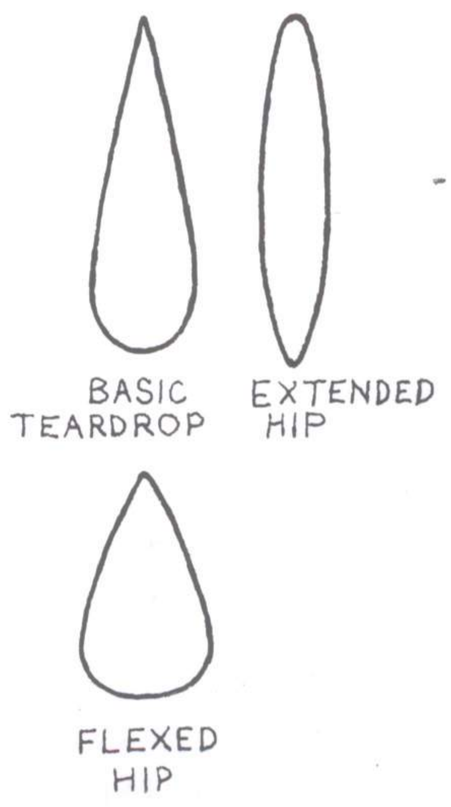
When the thigh is partly flexed at the hip joint and then medially rotated, the tensor fascia lata partially or completely merges with the anterior portion of the gluteus medius to produce a single, oval, bulging form. When they are distinct from each other, the gluteus medius extends to the bottom of the front edge of the greater trochanter, whereas the tensor descends lower and does not attach to the greater trochanter. The tensor muscle is separated from the greater trochanter by fleshy fibers of the gluteus medius.

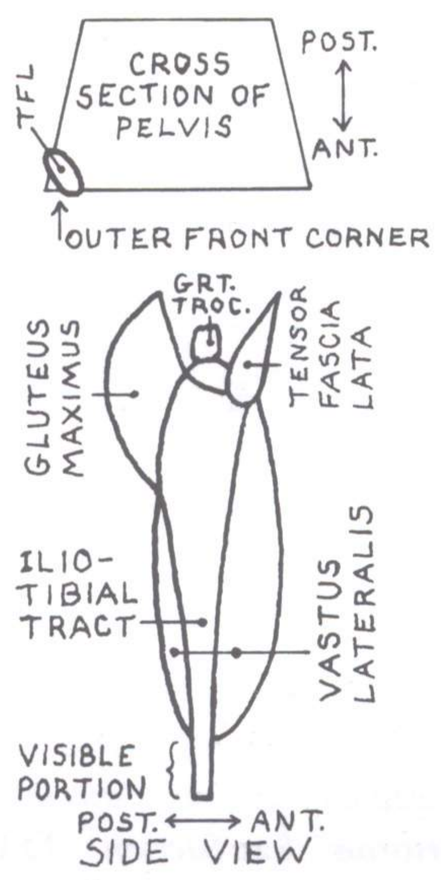
The lower end of the tensor muscle is often the widest point of the male hips.

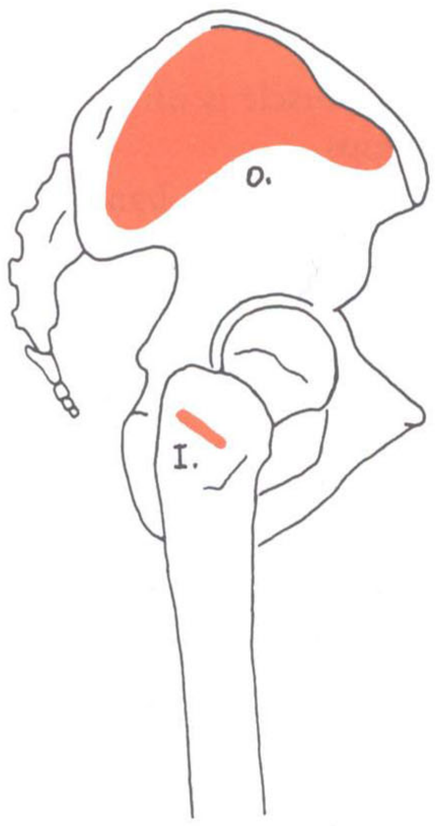
The **iliotibial tract** is a long, wide, thin band that lies on the outer surface of the thigh. It begins superiorly at the level of the greater trochanter and ends inferiorly where it distinctly inserts into the lateral condyle of the tibia. This tract is a *thickening of the normal fascia* that surrounds the entire leg. Both the tensor fascia lata and gluteus maximus insert into its upper end, and the tract functions as their tendon of insertion into the tibia below (it is technically fascia, not tendon). The iliotibial tract wraps around the posterior surface of the vastus lateralis and fuses with the lateral intermuscular septum, which eventually attaches to the linea aspera on the back of the femur.

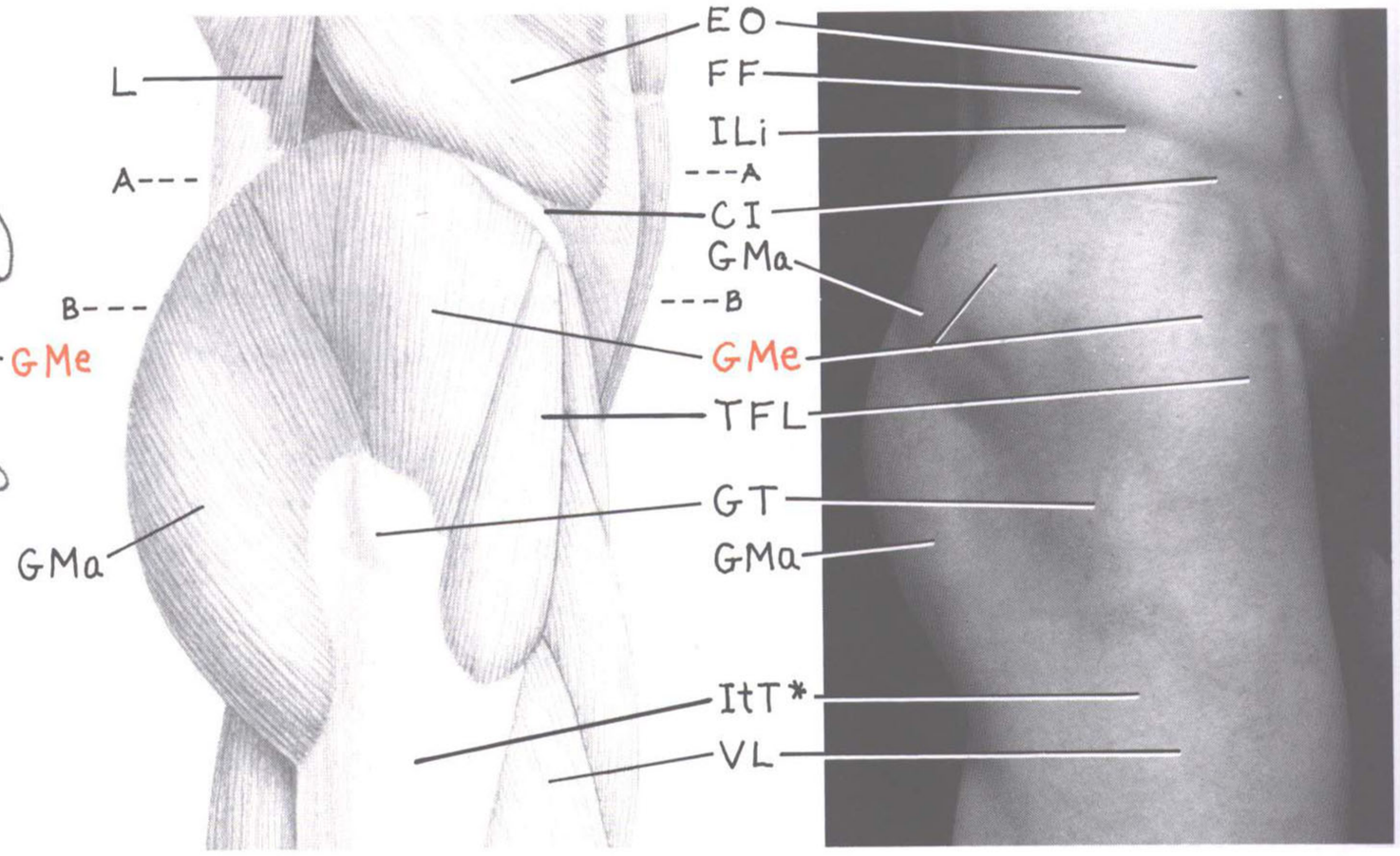
When the muscles of the leg are tensed, the lower end of the iliotibial tract regularly shows up as a distinct, narrow, vertical form on the outside of the extended knee (after it passes *off* the form of the vastus lateralis). There are no muscle fibers in this form. Its posterior edge continues downward from the posterior edge of the vastus lateralis (seen in side view). This form lies anterior to the belly of the short head of the biceps femoris and is in contact with it or is separated from it by a narrow interval.

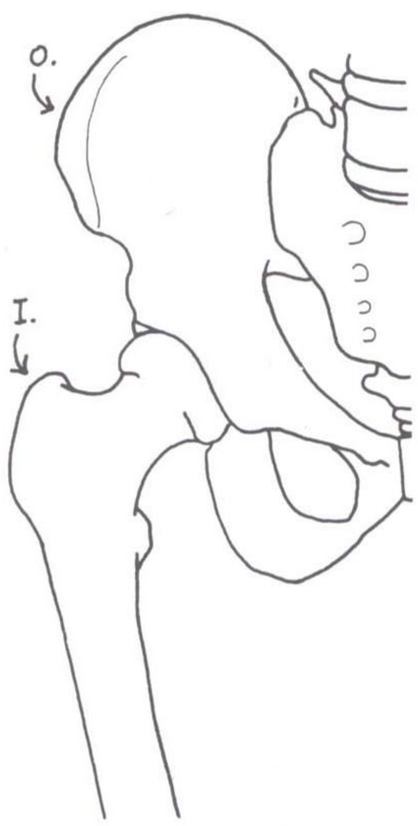
As it lies on the vastus lateralis, the thin iliotibial tract has no form of its own. But when pulled taut by the two muscles that attach into its upper end, the iliotibial tract creates numerous long, vertical furrows and ridges in the underlying vastus lateralis muscle mass, much like a pillowcase would do when pulled tight against the surface of a soft pillow inside it (see Vastus Lateralis).

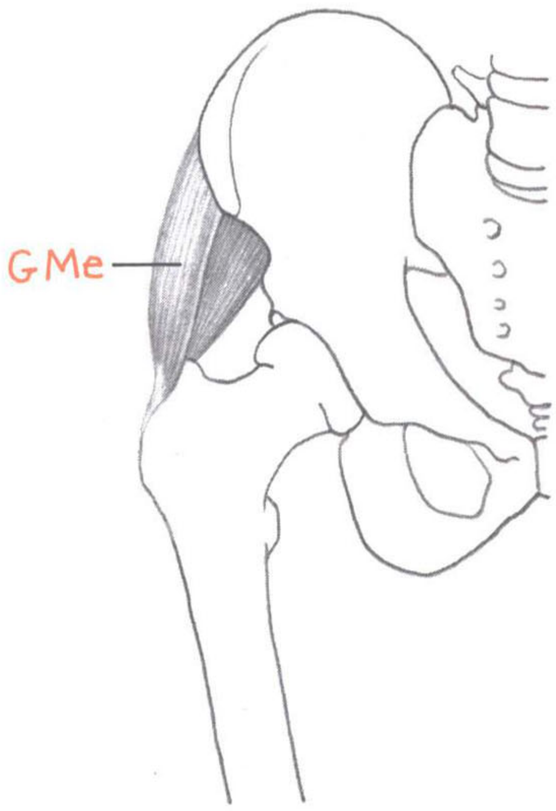


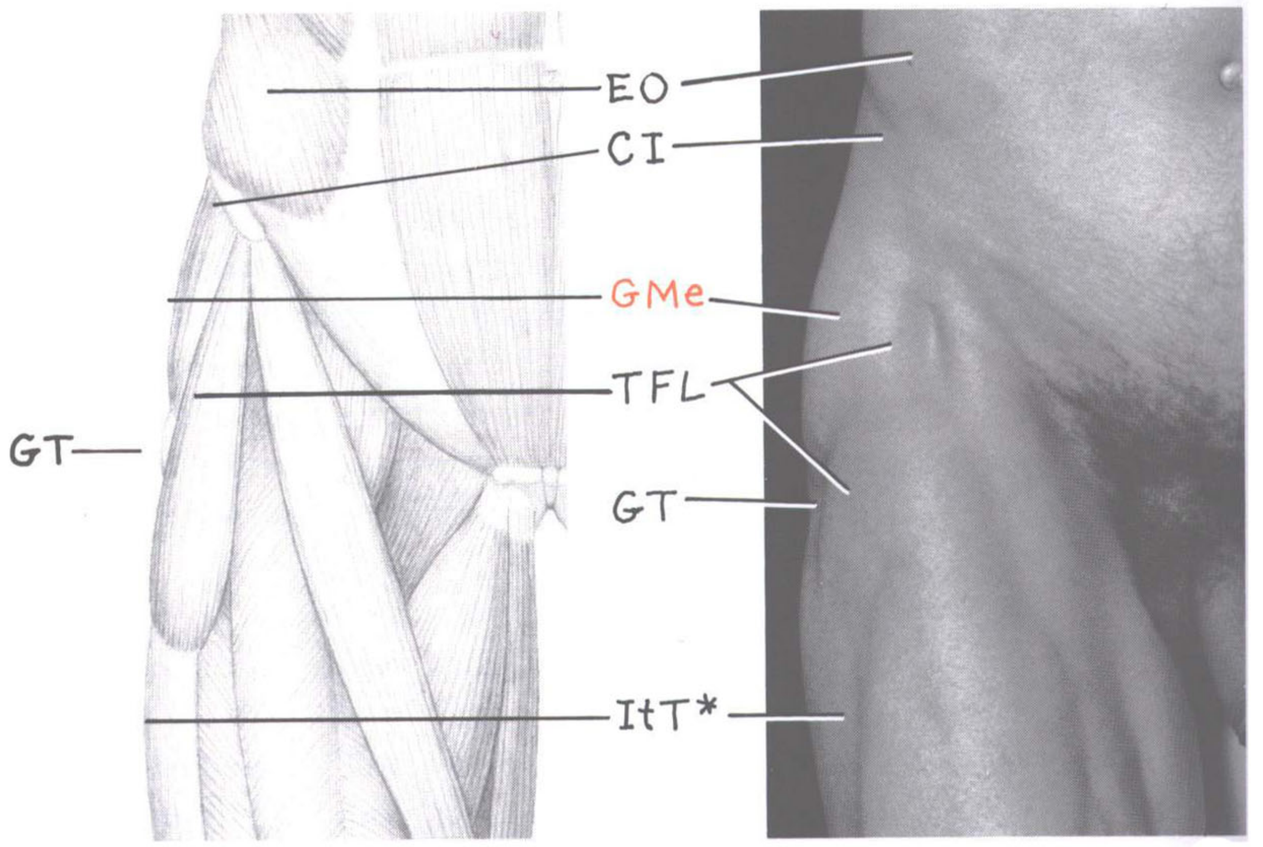


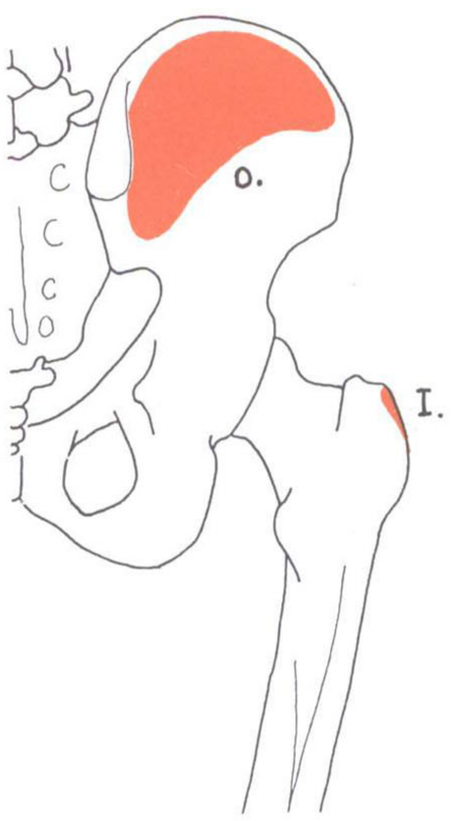


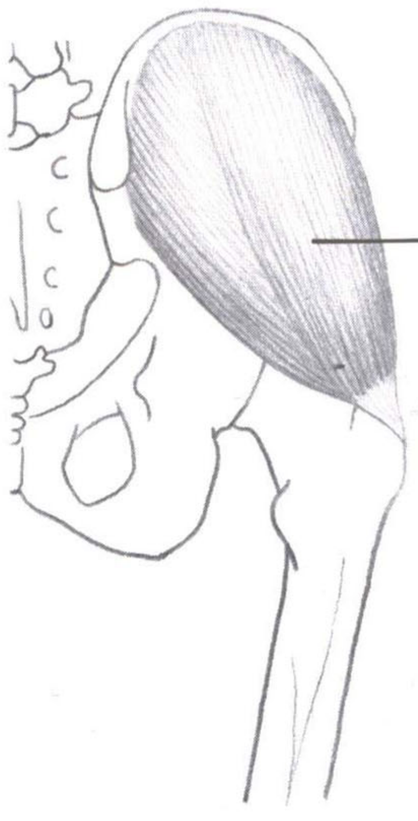


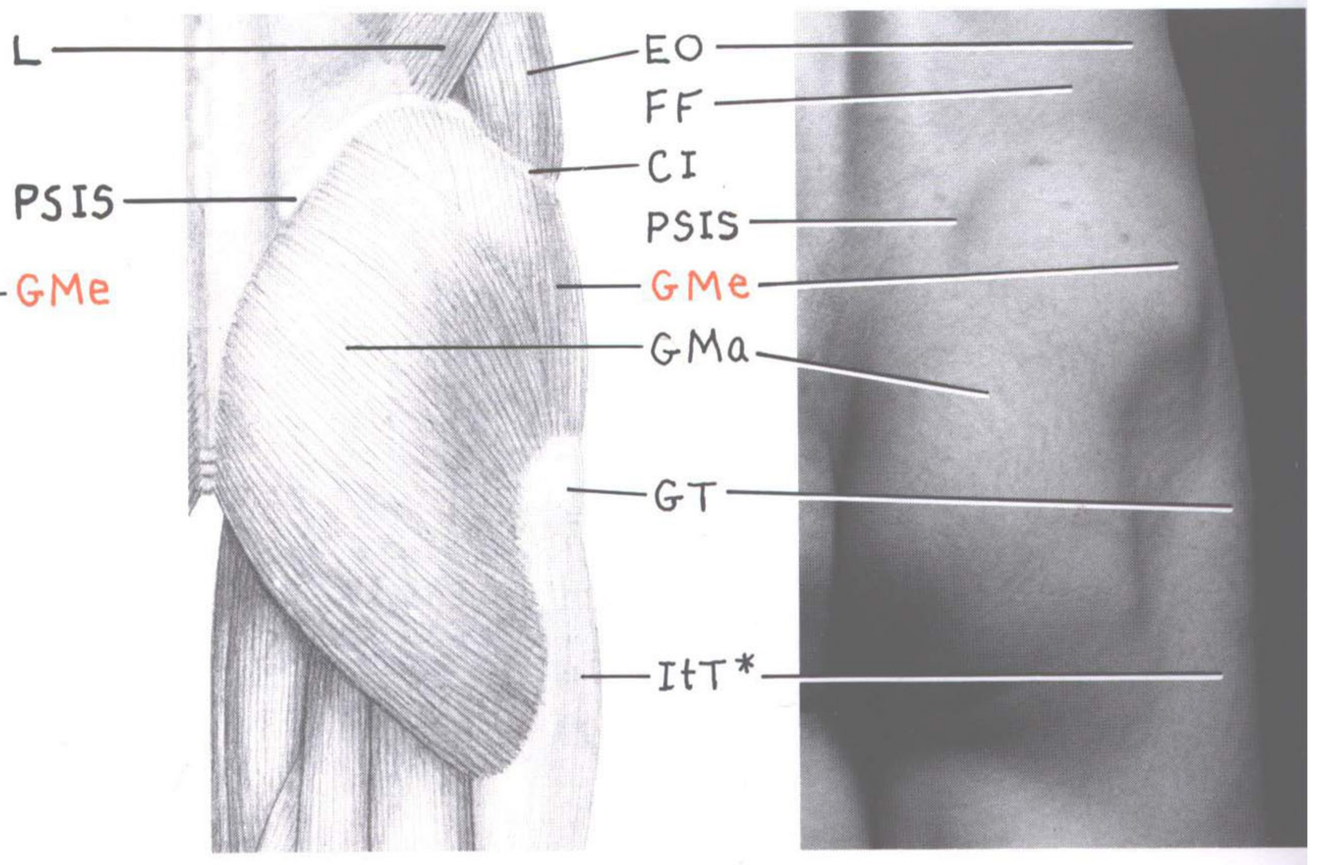




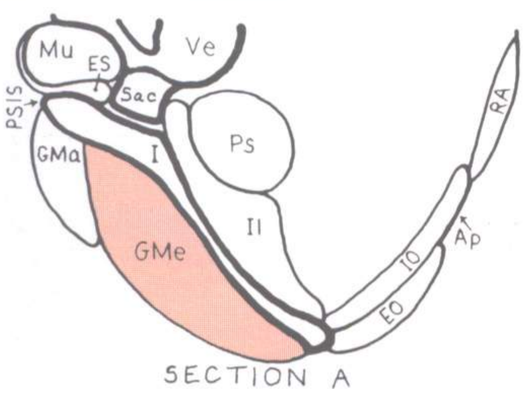


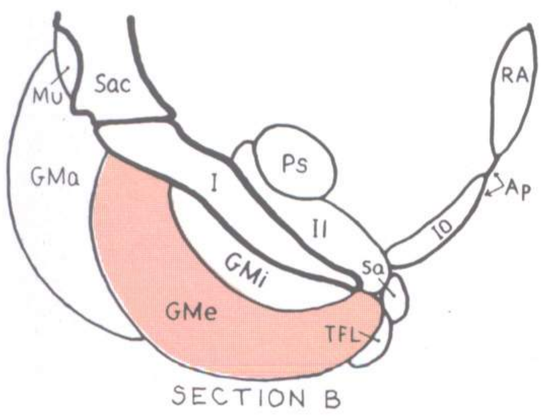






CI *Crest of ilium* **EO** *External oblique* **FF** *Flank fat pad* **GMa** *Gluteus maximus*
GMe *Gluteus medius* **GMi** *Gluteus minimus* **GT** *Greater trochanter* **I** *Ilium* **Il** *Iliacus* **ILi** *Iliac line*
ItT *Iliotibial tract (on vastus lateralis)* **L** *Latissimus dorsi* **PSIS** *Posterior superior iliac spine*
Sa *Sartorius* **Sac** *Sacrum* **TFL** *Tensor fascia lata* **VL** *Vastus lateralis*





Gluteus Medius

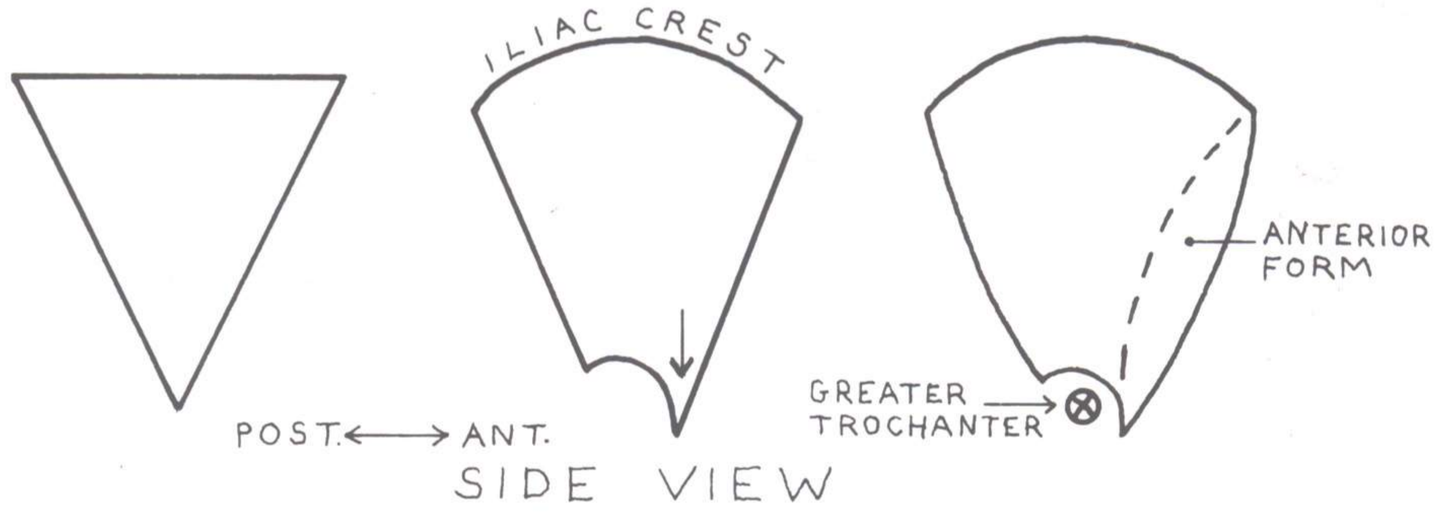
ORIGIN Outer surface of a portion of the ilium (pelvis), up to the crest of the ilium.

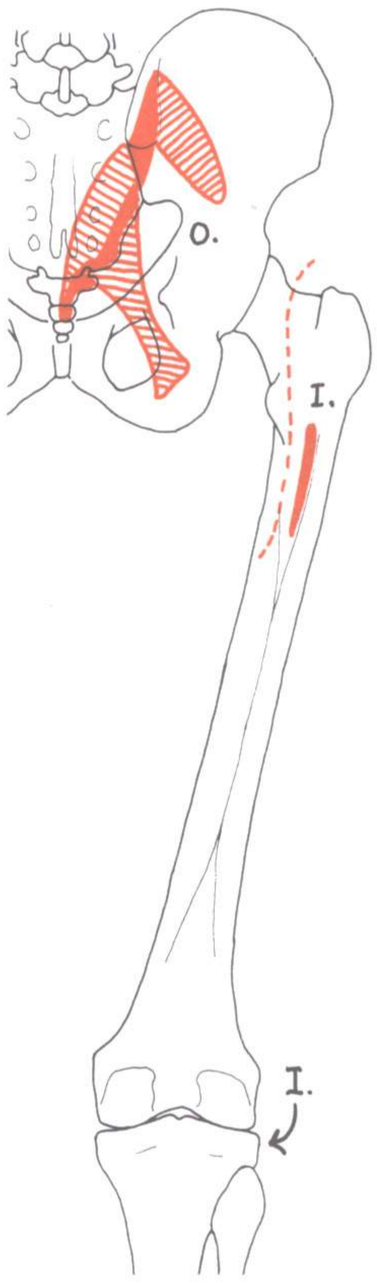
INSERTION A wide oblique line running downward and forward on the outer (lateral) surface of the greater trochanter of the femur.

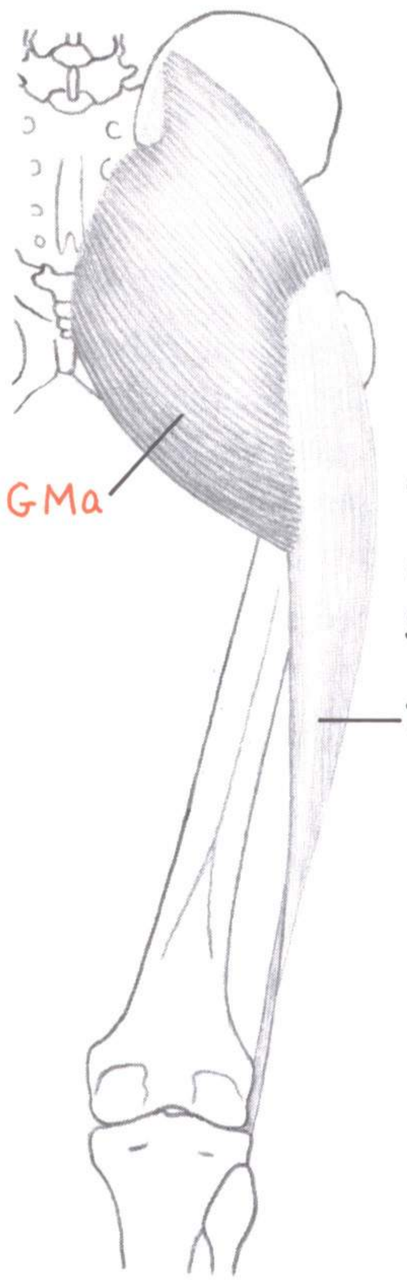
ACTION Abducts the thigh; keeps the pelvis horizontal during walking when the advancing leg is not in contact with the ground. Posterior fibers extend and laterally rotate the thigh; anterior fibers medially rotate the thigh.

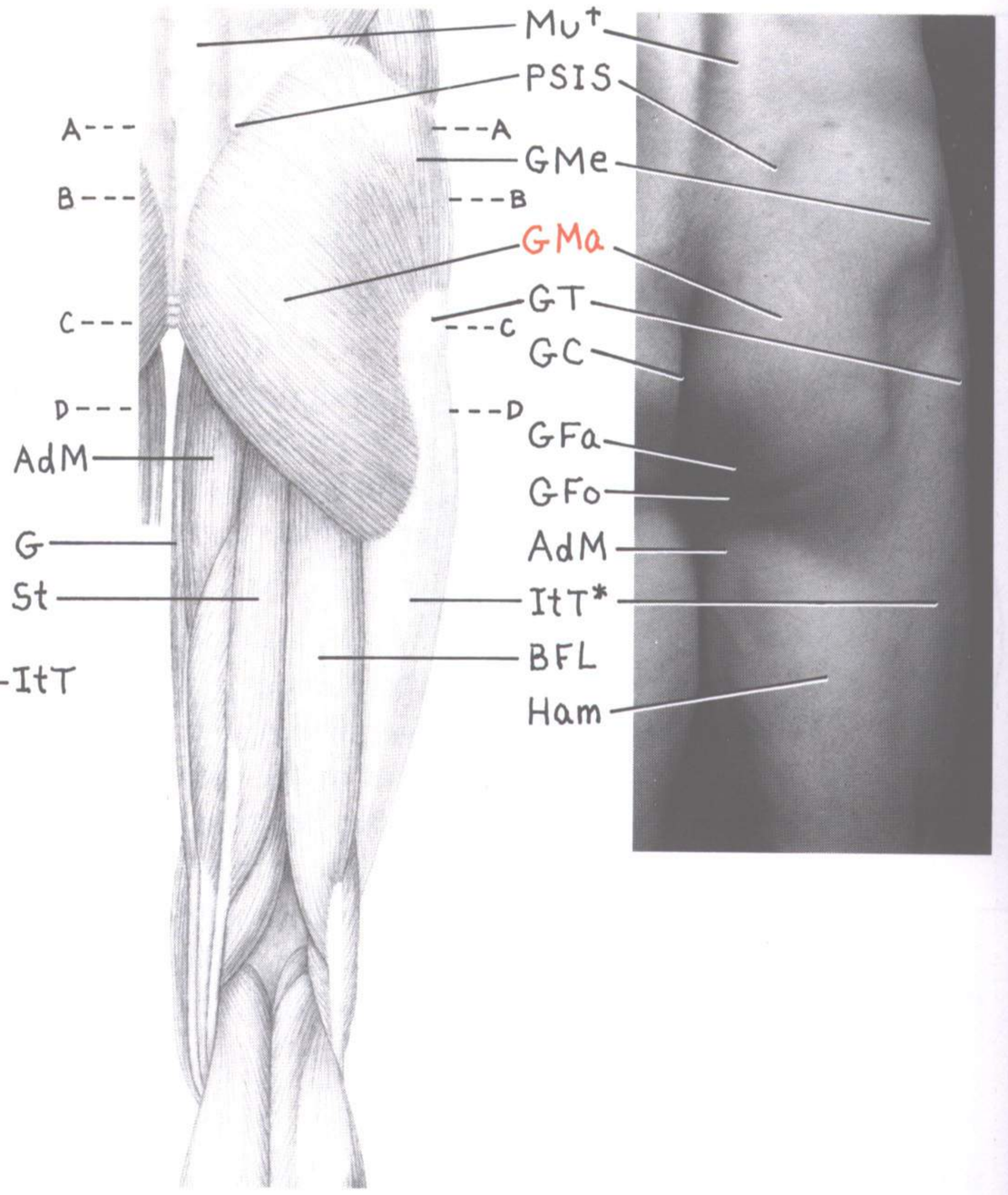
STRUCTURE The gluteus medius is a wide, thick, fan-shaped muscle that tapers inferiorly into a strong flattened tendon at its insertion. The mass of the muscle ends on top and in front of the greater trochanter; its tendon (not visible) continues downward and posteriorly over the surface of the greater trochanter to the actual line of insertion. The form of the greater trochanter is therefore not covered by muscle fibers and is visible. The anterior fibers of the gluteus medius continue down the front edge of the greater trochanter for a short distance; they can bulge quite considerably during flexion and medial rotation of the femur. This anterior bulge, separate and distinct from the rest of the gluteus medius, is often confused with the tensor fascia lata, but the tensor muscle's form begins from a very small area of origin on the outer front corner of the ilium and ends lower on the thigh than does the gluteus medius (the tensor ends on the surface of the vastus lateralis). The anterior form of the gluteus medius is pointed inferiorly.

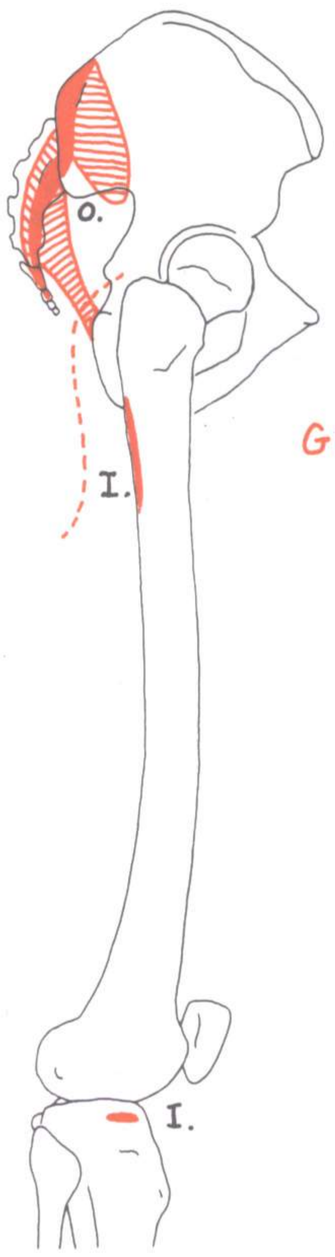
The posterior edge of the posterior portion of the gluteus medius is covered by the gluteus maximus. The line between these muscles is occasionally visible, and then only subtly. The posterior portion of the gluteus medius and the anterior portion of the gluteus maximus usually create a single, large, hemispherical form on the outer back corner of the pelvic region when both are tensed.

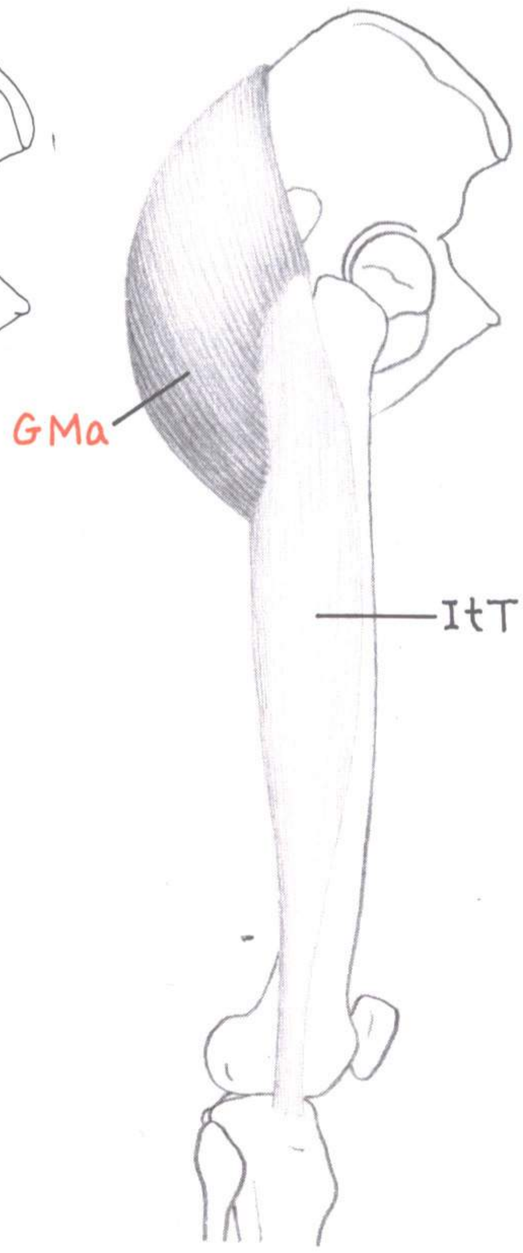


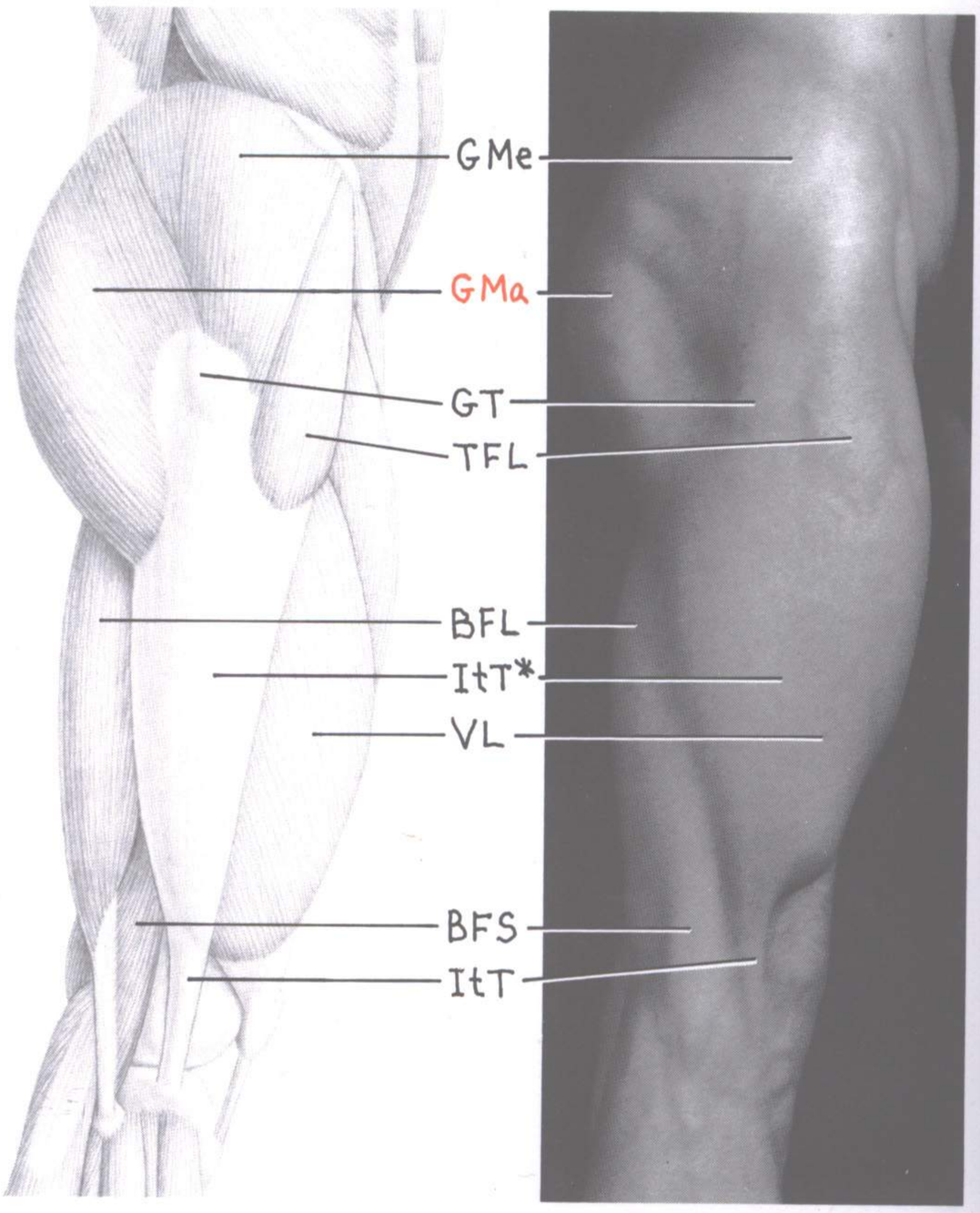




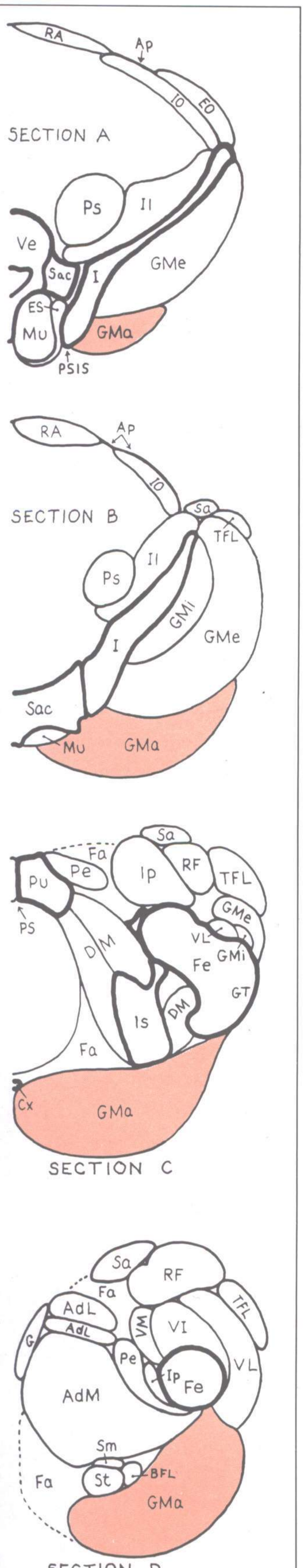








AdM *Adductor magnus* **BFL** *Biceps femoris—long head* **BFS** *Biceps femoris—short head*
Cx *Coccyx* **DM** *Deep muscle* **ES** *Erector spinae* **Fa** *Fat* **Fe** *Femur* **G** *Gracilis*
GC *Gluteal cleft* **GFa** *Gluteal fat pad* **GFo** *Gluteal fold* **GMa** *Gluteus maximus*
GMe *Gluteus medius* **GT** *Greater trochanter* **Ham** *Hamstring muscles* **I** *Ilium* **Is** *Ischium*
ItT *Iliotibial tract* **Mu** *Multifidus* **PSIS** *Posterior superior iliac spine* **Sac** *Sacrum*
Sm *Semimembranosus* **St** *Semitendinosus* **TFL** *Tensor fascia lata* **VL** *Vastus lateralis*
* *On vastus lateralis* † *Under erector spinae*



Gluteus Maximus

ORIGIN Expanded and roughened posterior fourth or fifth of the crest of the ilium, including the posterior superior iliac spine and the small area below it on the outer surface of the ilium; the posterior surfaces of the lateral edges of the sacrum's lower half and the coccyx (not from the last two coccygeal vertebrae); the sacrotuberous ligament between the sacrum and ischial tuberosity; the sacroiliac ligaments between the sacrum and ilium; the lateral surface of the aponeurosis of the erector spinae (which lies on the multifidus); and the surface of the posterior portion of the gluteus medius.

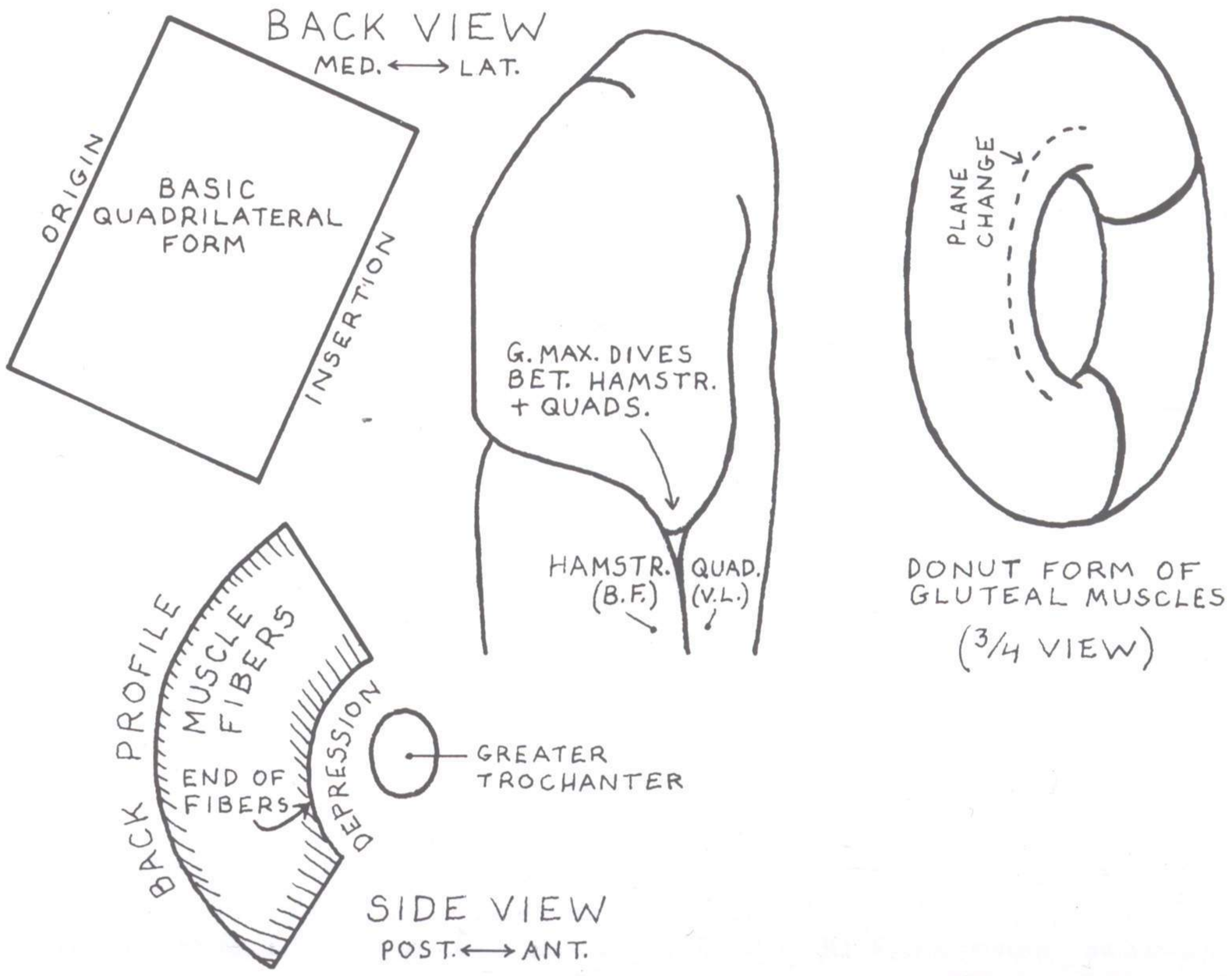
INSERTION *Upper half:* Upper portion of the iliotibial tract, which ultimately inserts into the lateral condyle of the tibia. *Lower half:* Superficial fibers into the iliotibial tract; deep fibers into the gluteal tuberosity of the femur, which is a thickened vertical line (an upward extension of the linea aspera) on the back of the femur.

ACTION Powerfully extends and laterally rotates the thigh at the hip joint; extends the pelvis when it is flexed forward. The upper fibers assist in abducting the thigh; the lower fibers assist in adducting it.

STRUCTURE The gluteus maximus is a thick, fleshy, quadrilateral muscle that forms the major volume of the buttock. It is directed downward and outward from its origin and wraps around the outer back corner of the pelvis. It consists of coarse muscle fibers which may at times form several wide, elongated bundles on the surface. The upper edge of the muscle is faintly indicated by a slight furrow where it overlaps the posterior portion of the gluteus medius. Its lower edge, passing from the bottom of the coccyx down to the outside of the leg, is concealed in the standing leg by a crescent-shaped fat pad that lies on the lower inner corner of the muscle. When the hip joint is completely flexed, the lower edge of the muscle may occasionally be seen in its entirety. The gluteus maximus covers the back but not the bottom of the ischial tuberosity, even when the hip joint is flexed, which prevents muscle fibers from getting damaged in the sitting position.

The gluteus maximus and the posterior half of the gluteus medius create a somewhat doughnut-shaped form on the outer back corner of the pelvis. Its back profile (seen in side view) is sometimes rounded almost into a perfect arc of a circle. The lower half of the arc straightens when the muscle is tensed (without the hip joint moving).

The inferior end of the form of the gluteus maximus, on the outer back corner of the thigh, is directed *between* the forms of the vastus lateralis and the long head of the biceps femoris



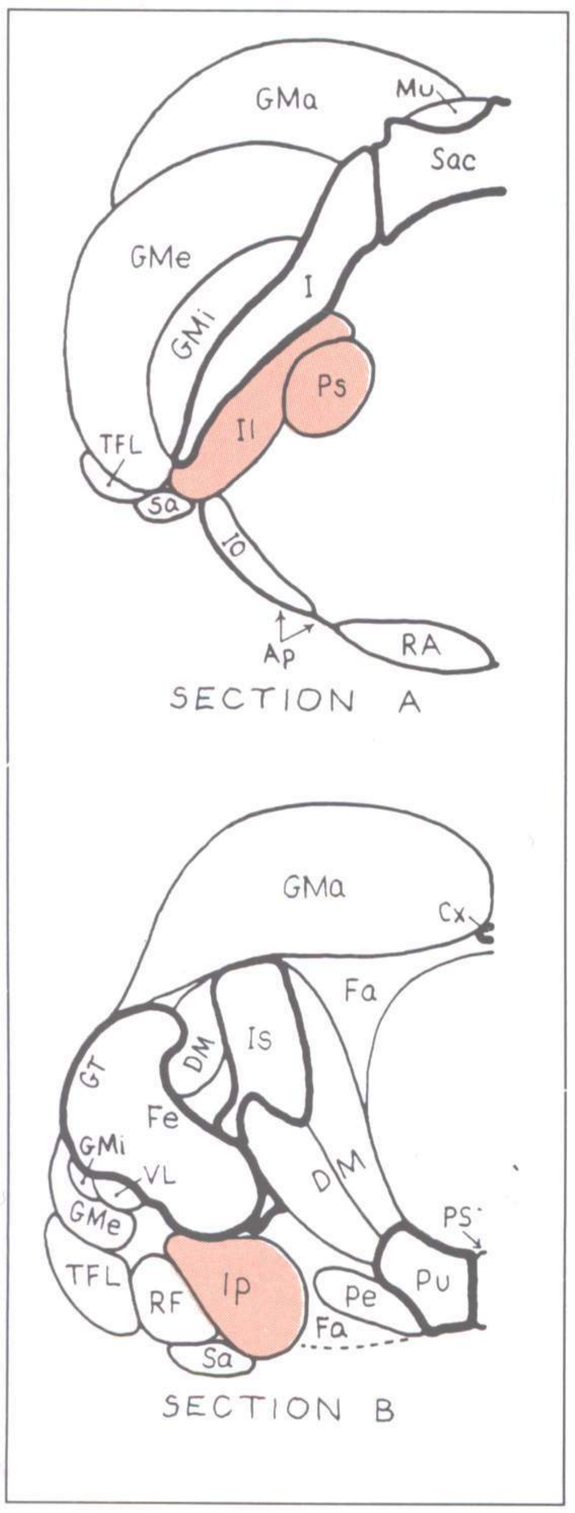
to its insertion into the femur, as well as onto the *posterior* surface of the mass of the vastus lateralis. This is because the fibers of the gluteus maximus attach into the iliotibial tract after the tract has wrapped around to the *posterior* surface (not the lateral surface) of the vastus lateralis. The gluteal form ends inferiorly more than one-third of the way down the thigh (between the iliac crest and knee joint).

A band of fascia, the **gluteal band,** crosses the lower portion of the muscle and produces a sharp, deep, horizontal skin fold when the leg is extended at the hip joint. This fold disappears as the hip joint is flexed.

From the back view, the entire buttocks appears slightly wider than high. The form of the muscles of both sides meet at the midline and create the vertical **gluteal cleft,** which ends superiorly a short distance above the tip of the coccyx. When the gluteus maximus is tensed in the standing position, it becomes narrower, because the fibers become shorter. As the hip is flexed, the gluteus maximus elongates and flattens, and the bony points of the pelvis and sacrum begin to project, especially the posterior superior iliac spine. In the standing position, this spine is usually seen as a depression, because the fleshy fibers at the origin of the gluteus maximus bulge where they surround, but don't actually cover, the tip of the spine. Fat located in this area, especially in the female, also surrounds but does not cover the tip, deepening the depression into a dimple.

The inferiorly pointed **sacral triangle** is defined by a horizontal line drawn between the dimples or points of the posterior superior iliac spines and by oblique lines drawn from these posterior pelvic points down to the top of the gluteal cleft. The oblique lines correspond to the line of origin of the gluteus maximus, and because this muscle originates from the surface of the aponeurosis of the erector spinae, the sacral triangle is *smaller* than the actual size of the bony sacrum.

On the *side* of the hip, the form of the gluteus maximus ends where its muscle fibers attach into the iliotibial tract. A depression forms between this line and the greater trochanter. This area deepens when weight is placed on the straight standing leg and becomes shallower when weight is removed. During strong contractions, one or two thin, narrow, vertical forms are occasionally seen in this depression posterior to the greater trochanter—they are deep fibers of the gluteus maximus lying under the iliotibial band. The depression helps create the doughnut-shaped form on the outer back corner of the hip. When the gluteal muscles are tensed, the area above the depression bulges into a prominent hemispherical form, created by the posterior portion of the gluteus medius and the anterior portion of the gluteus maximus. When the hip joint is fully flexed, fibers of the gluteus maximus slide over the greater trochanter and conceal it.



Iliopsoas
(Iliacus and Psoas Major)

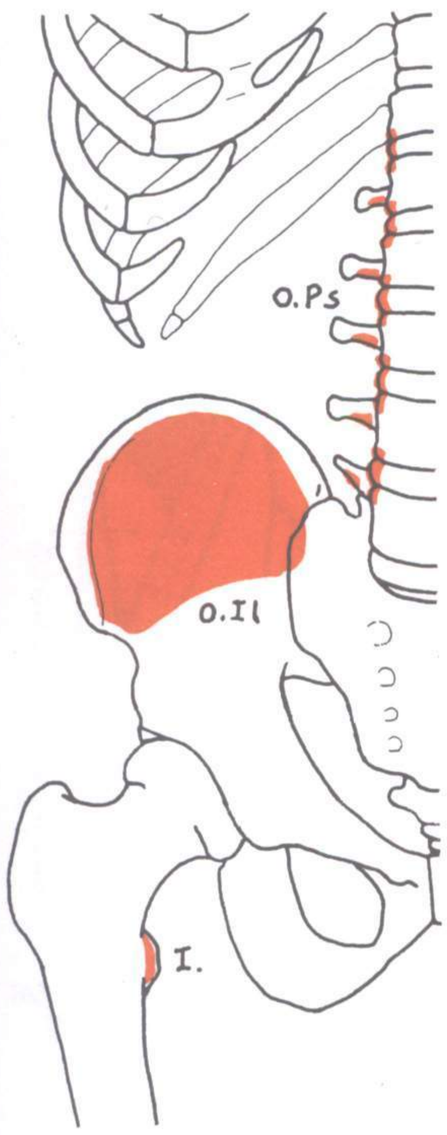
ORIGIN *Iliacus:* Upper two-thirds of the iliac fossa and the base of the sacrum. *Psoas major:* Anterior surfaces and lower borders of the transverse processes of all the lumbar vertebrae; by five slips from the upper and lower margins of the sides of the bodies of the vertebrae and the intervening intervertebral discs, beginning from the lower margin of the last thoracic vertebra and ending at the upper margin of the fifth lumbar vertebra.

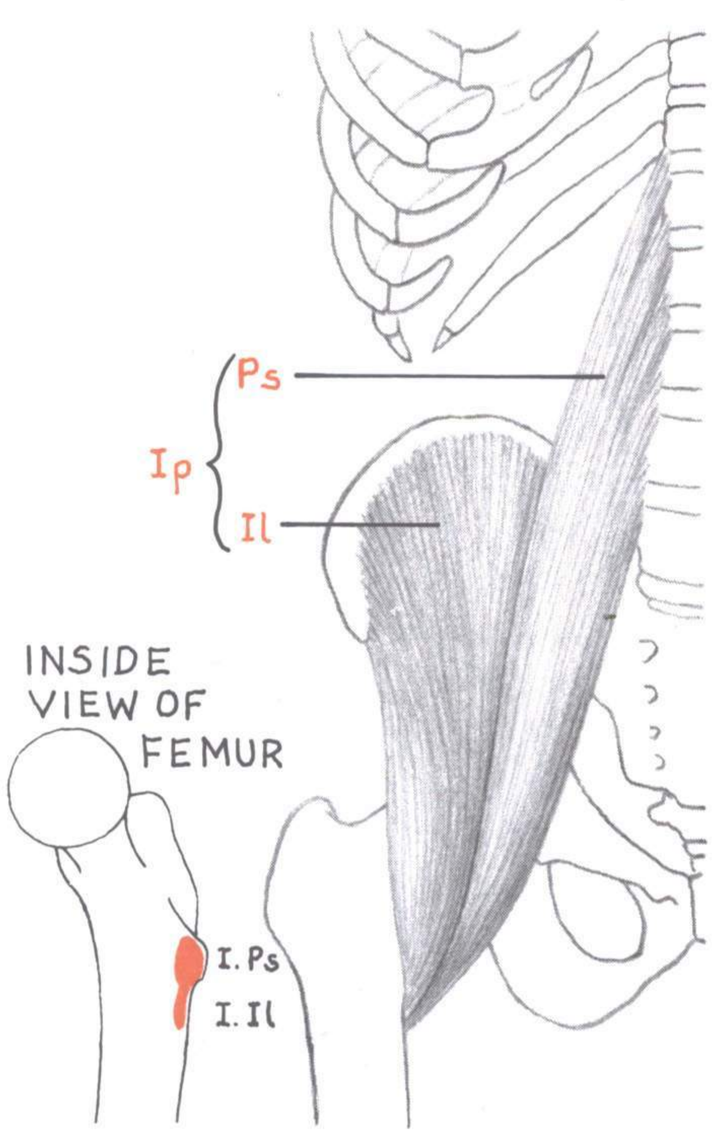
INSERTION *Iliacus:* Lateral side of the tendon of insertion of the psoas major and onto the shaft of the femur for an inch or so immediately below and anterior to lesser trochanter. *Psoas major:* Lesser trochanter of the femur.

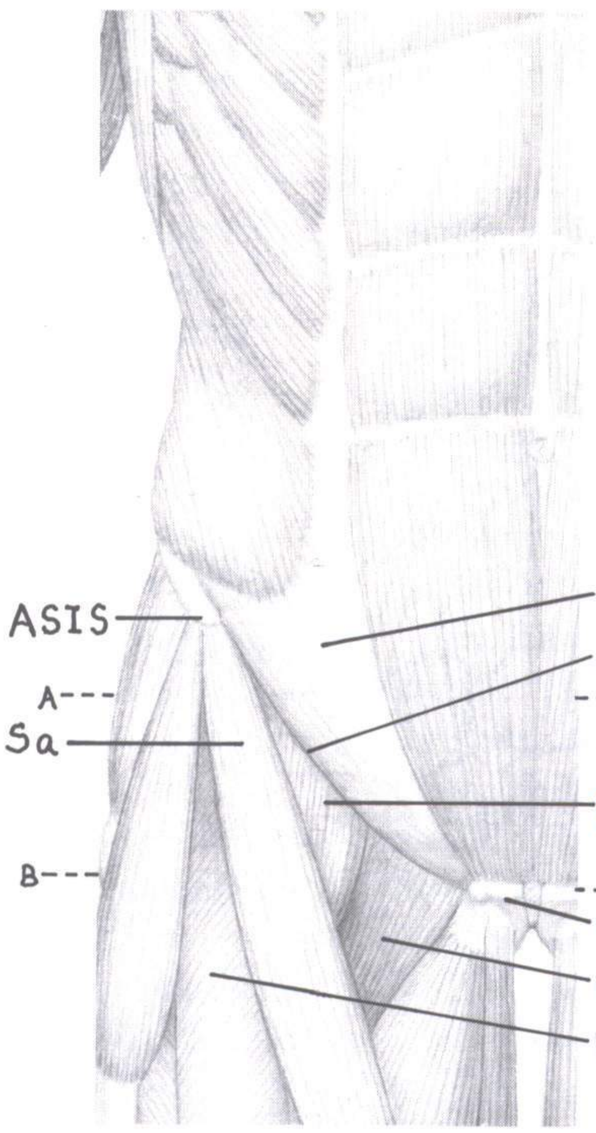
ACTION Powerful flexor of the hip joint; it flexes the thigh (when kicking) or pelvis (and trunk—when doing a sit-up). It also laterally rotates the thigh. The psoas assists in flexing the lumbar vertebrae.

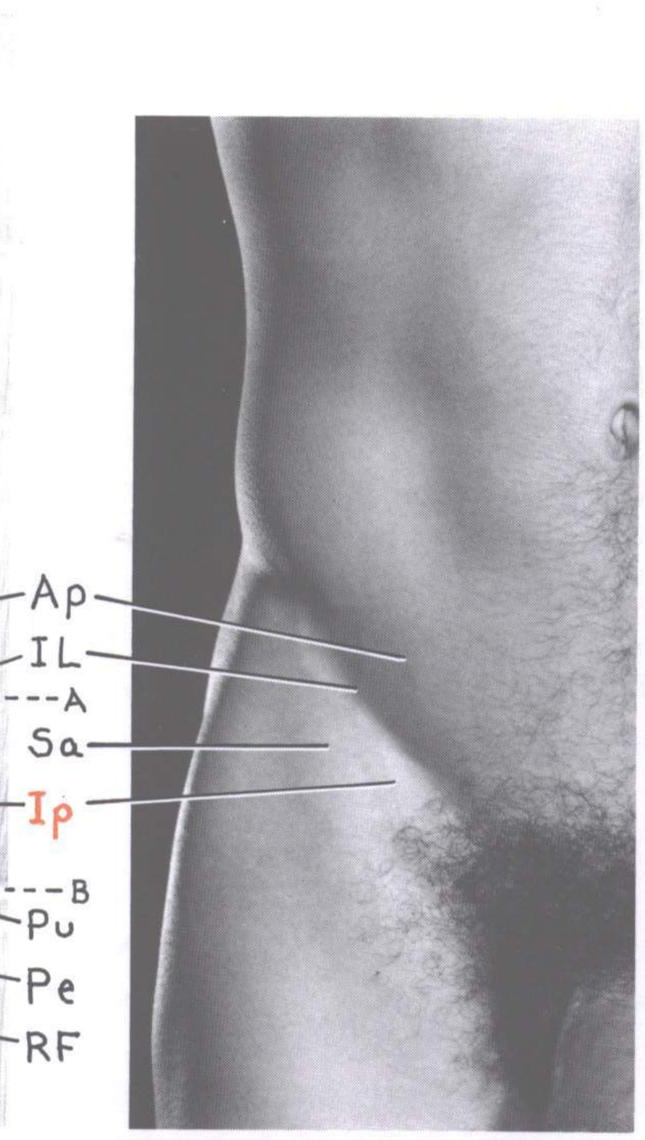
STRUCTURE The iliopsoas is made up of the large, flat, triangular **iliacus** and the fusiform **psoas major.** Considered as a single muscle group, it begins deep in the back of the abdomen and converges toward its insertion on the inner back corner of the femur. It passes down the bony notch on the front of the acetabulum of the pelvis (directly in front of the hip joint), just below the anterior *inferior* iliac spine. Coursing downward under the inguinal ligament, the iliopsoas becomes partly subcutaneous as it leaves the abdomen, but soon disappears as it dives deep.

The iliopsoas is never prominent. It lies partially under the upper end of the sartorius, which it pushes slightly forward in the extended hip. The superficial portion of the iliopsoas, primarily the iliacus, is located just medial to the superior end of the sartorius and immediately below the inguinal ligament. It bulges slightly when the hip is extended. This superficial portion becomes slightly recessed from the surface when the hip joint is flexed (as the sartorius is raised forward). Its form may be seen when the leg is abducted toward the horizontal and laterally rotated, at which time the superficial area is slightly recessed, but appears as a short, downwardly pointed triangular form.









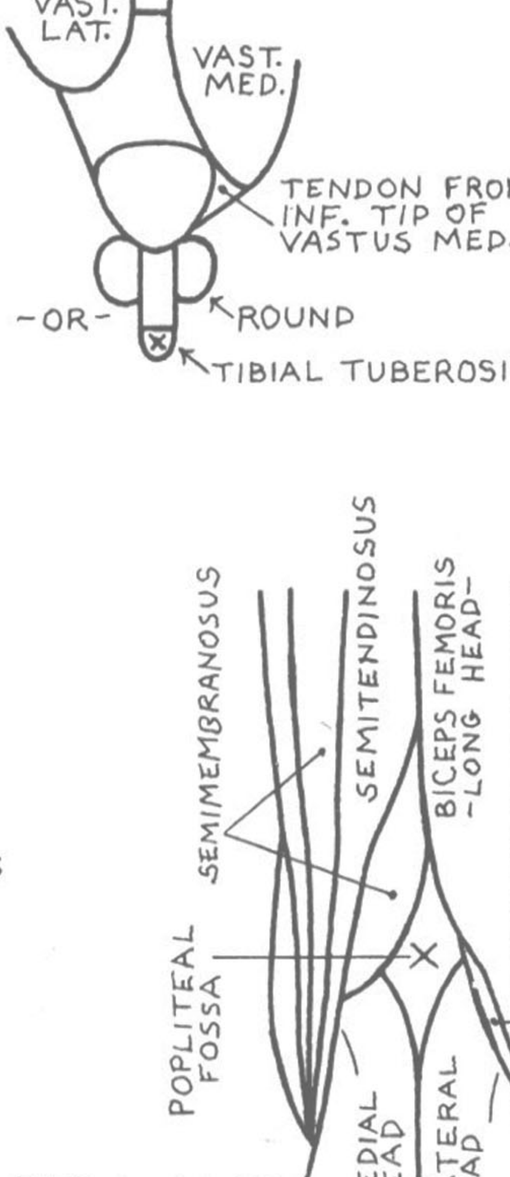
Ap *Aponeurosis of external oblique* **ASIS** *Anterior superior iliac spine* **Fa** *Fat* **Fe** *Femur* **GMe** *Gluteus medius* **I** *Ilium* **IL** *Inguinal ligament* **Il** *Iliacus* **IO** *Internal oblique* **Ip** *Iliopsoas* **Pe** *Pectineus* **PS** *Pubic symphysis* **Ps** *Psoas major* **Pu** *Pubis* **RF** *Rectus femoris* **Sa** *Sartorius*

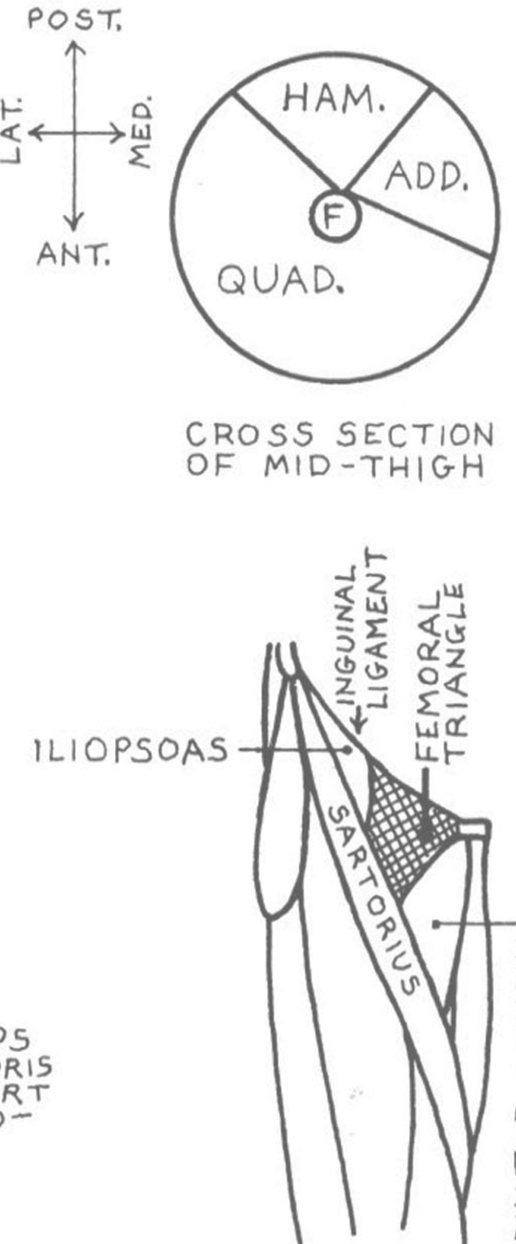
The Upper Leg Muscles

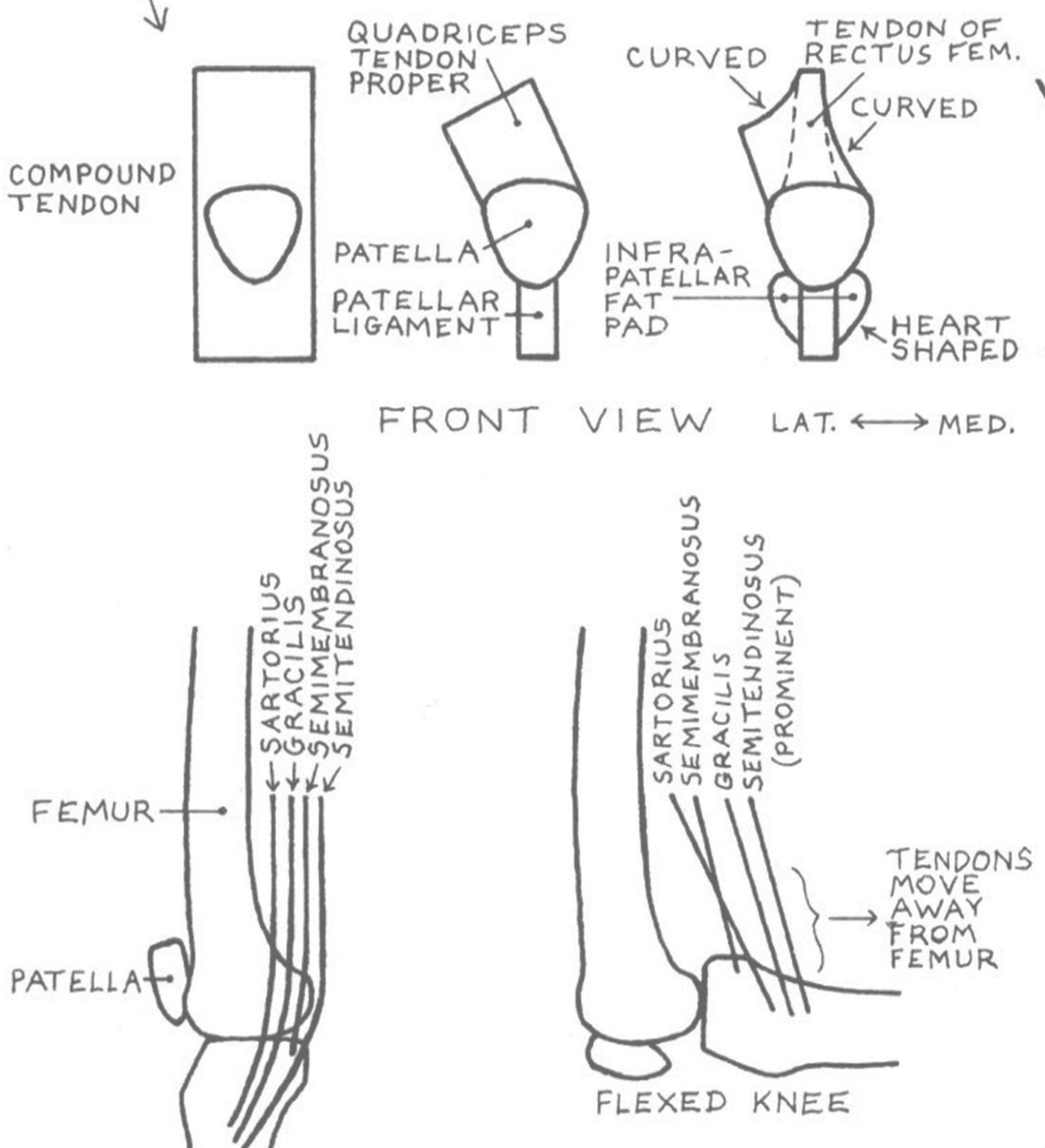
FORMS	QUADRICEPS	
1.	VASTUS MED.	FROM FEMUR
2.	VASTUS LAT.	
(DEEP)	VASTUS INTER.	
3.	RECTUS FEM.	FROM PELVIS

FORMS	HAMSTRINGS	
MED. GROUP 1.	SEMITEND.	FROM PELVIS
MED. GROUP 2.	SEMIMEMB.	
	BICEPS FEM.	
LAT. GROUP 3.	-LONG HEAD	
LAT. GROUP 4.	-SHORT HEAD	FROM FEMUR

ADDUCTORS		
FROM PELVIS	ADDUCTOR LONG.	TO FEMUR
	ADDUCTOR MAG.	
	GRACILIS	TO TIBIA







The Upper Leg Muscles

The *UPPER LEG*, or thigh, contains three muscle groups: the quadriceps, hamstrings, and adductors. The quadriceps has the largest mass; the hamstrings and adductors are about equal in volume. The relative size of the masses changes at different levels of the thigh. The overall shape of the thigh is a double-curved cylinder (elongated ovoid) that tapers inferiorly. The female thigh is relatively wider superiorly than the male thigh (because of the fat pads); therefore it has a greater degree of taper.

The **quadriceps femoris** is the muscle group located on the front of the thigh. It is an extremely large muscle mass which extends considerably around the femur, especially around the outside of the thigh. It contains four distinct muscular components—the vastus medialis, vastus lateralis, vastus intermedius, and rectus femoris—and their complex compound tendon of insertion. They all ultimately insert into the tibia after the compound tendon crosses the knee joint. The three vasti muscles originate from most of the available surface of the femur; they are one-joint muscles that cross the knee joint only and extend the knee. The rectus femoris, a two-joint muscle, originates from the pelvis and crosses both the hip and knee joints. It flexes the hip joint and extends the knee joint. Except for the vastus intermedius, which is deep to the other muscles, the quadriceps femoris group is often highly defined on the surface when tensed.

The **compound tendon of the quadriceps** connects the massive quadriceps muscle to the tibial tuberosity below. It is divided into four components: the quadriceps tendon proper, rectus femoris tendon, patellar portion of the tendon, and patellar ligament. The superior portion, located above the patella, is the **quadriceps tendon** proper. This tendon is basically a quadrilateral plane, curved side to side, that faces anteriorly and slightly laterally. It is slightly oblique, its upper end shifting laterally. The surface is recessed slightly owing to the projection of the surrounding musculature and patella. The three vasti muscles attach into the periphery of the tendon, which in turn attaches mostly to the top, and partly to the sides, of the patella (the fibers of the vastus medialis also attach directly to the patella). When the knee is flexed, the sharp front edge of the lateral condyle of the femur becomes visible under the quadriceps tendon. There are no muscle fibers located deep to this tendon, only fat.

In the female, a fat pad on top of the quadriceps tendon usually obscures the definition of the lower margins of the quadriceps bellies where they attach to the tendon, even in thin females.

The **tendon of the rectus femoris** is a separate structure, coming from the inferior end of the rectus femoris, that is closely applied to the surface of the quadriceps tendon. This narrow tendon is occasionally seen in relief during partial flexion of the knee when the quadriceps is tensed. The rectus femoris tendon also attaches to the top of the patella.

The rectus femoris and quadriceps tendons partially attach to the top of the patella, but they also continue onward to pass downward over the front surface of the patella, inseparably adhering to it. This portion can be called the **patellar portion of the quadriceps tendon.** The patella can be thought of as being embedded into the tendon of insertion of the quadriceps muscle. The function of the patella is to displace the quadriceps tendon away from the center of the knee joint, thereby giving the quadriceps muscle greater mechanical advantage.

The final portion of the compound tendon passes from the bottom of the patella to the tibial tuberosity. Because it connects these two bones, it is called the **patellar ligament,** but could more correctly be called the patellar *tendon*, since it is a true tendon of a muscle. The patellar ligament is directed downward and occasionally slightly laterally. It is a thick, strong, rectangular tendon.

The length of the patellar ligament does not change (it does not stretch). As the tibia rolls around the condyles of the femur in knee flexion, it pulls the patella downward and backward. The quadriceps pulls the patella forward and upward during knee extension. In both flexion and extension, the patella glides over the femoral condyles, and the distance between the patella and tibial tuberosity never changes. In the straight, extended knee, a horizontal skin furrow is sometimes seen where the patellar ligament attaches to the bottom of the patella; the fat pad behind the ligament bulges on either side of the ligament, often obscuring it. This ligament is most clearly seen when the knee is in partial flexion—the fat pad slides into the increased joint space and the ligament meets the inferior apex of the patella at an angle (best seen in side view).

The **hamstring muscle group** consists of three muscles located on the back of the upper leg. The term *hamstrings* actually refers to their tendons. This group consists of the semimembranosus, semitendinosus, and biceps femoris. The biceps femoris has two heads, a long and a short. The hamstring group therefore contains a total of four muscular heads (four forms), all of which eventually insert into the lower leg, past the knee joint. The semimembranosus, semitendinosus, and long head of the biceps, all two-joint muscles, originate on the pelvis. They extend the hip joint and flex the knee joint. The short head of the biceps, a one-joint muscle,

originates on the femur and can only flex the knee. The hamstrings divide on the back of the knee into medial and lateral groups—the semimembranosus and semitendinosus pass medially to the inside of the tibia, and both heads of the biceps pass laterally to the head of the fibula.

As the knee joint is flexed, the lower ends of the hamstrings pull away from the back of the femur (they shift posteriorly) because of their insertions on the lower leg some distance below the knee joint. This thickens the lower end of the thigh from front to back as the knee is flexed. In the flexed knee, the tendons of the semitendinosus and biceps femoris often become very prominent.

In the standing position, the separate bellies of the hamstring muscles are not readily differentiated on the surface. They are individually recognizable when stretched to their longest limit if the knee is kept straight and the pelvis is completely flexed forward at the hip joint. The long head of the biceps femoris is wider than the semitendinosus, and the semitendinosus and semimembranosus together are wider than the biceps.

The area of the back of the knee between the hamstring tendons is called the **popliteal region.** It contains the **popliteal fat pad.** When the knee is straight, this fat pad and part of the belly of the semimembranosus project posteriorly, forming the **popliteal bulge.** This bulge is bordered medially by a vertical furrow created by the recessed tendon of the semitendinosus and laterally by a vertical furrow created by the medial edge of the biceps femoris tendon. These furrows usually end inferiorly at the horizontal skin flexion fold on the back of the knee joint. The medial furrow often descends past the horizontal fold. When the knee is flexed, the hamstring tendons on either side of the back of the knee become prominent (the fat sinks in), and a depression, the **popliteal fossa,** develops between the tendons.

Occasionally, two nerves may appear on the surface in the popliteal region. The tibial nerve passes down the center of the back of the knee, and the common peroneal nerve passes downward along the posterior edge (medial edge) of the short head of the biceps femoris and its tendon.

The **adductor muscle group** lies on the inside of the thigh. Its superficial muscles are the adductor longus, adductor magnus, and gracilis. There are other muscles belonging to this group, but they are smaller, deeper, and do not influence surface form. The adductor muscles originate from the bottom of the pelvis, between the pubic symphysis and ischial tuberosity. They insert for the most part on a line passing down the back of the femur that veers medially at its inferior end (the gracilis crosses the knee joint to insert into the tibia). The adductors therefore originate from a short horizontal line and insert into a long vertical line. They expand considerably into a large muscle mass between their attachments.

The adductor mass can be visualized as an inverted cone whose internal (deep) side flattens into a tendinous edge. This enables it to squeeze between the quadriceps (vastus medialis) and hamstrings (adductor magnus) to reach its narrow insertion on the femur. The top of the inner front corner of the adductor mass (at the midline of the body) is squared-off because the adductor longus originates on the front of the pubic bone just lateral to the pubic symphysis. Because of the wider angle of the bony pubic arch on the bottom of the pelvis in the female, the lines of origin of the adductors of both legs are farther from the midline than in the male, and a gap may be present between the upper ends of the thighs if the fat is thin.

Although the adductor group is a large, powerful muscle mass, very little energy is needed for normal adduction (gravity usually takes care of that). This group also flexes, extends, and stabilizes the hip joint, depending on the action and position of the femur.

The mass of the quadriceps is oblique, being directed downward and medially (front view). By contrast, the hamstrings are vertical, while the adductors are directed downward and laterally (toward the center of the thigh). The hamstrings and adductors usually blend together to form a single, large, oval muscle mass on the back and inner side of the thigh. This form is directed upward, inward, and forward. The individual muscles are usually not defined on the surface; however, they can all be found on the surface in certain poses in individuals with little fat. The adductors and quadriceps are usually separated by a furrow or valley in which the sartorius lies, while the hamstrings are almost always separated from the quadriceps on the side of the thigh (where the biceps femoris meets the vastus lateralis).

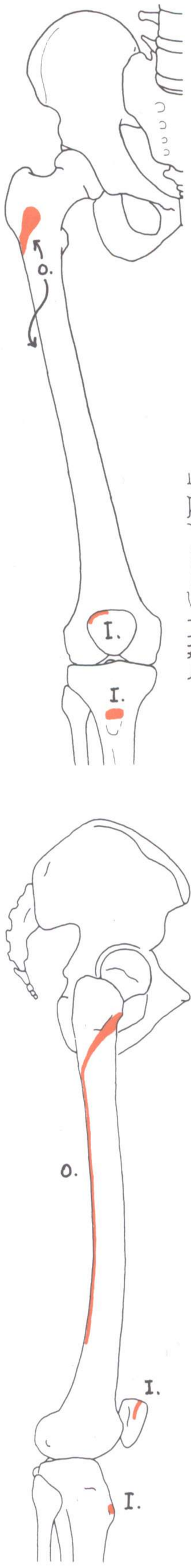
The thigh is cylindrical, the knee is boxlike, and the lower leg is triangular. The knee, although partly covered by muscle on both its inner and outer surfaces, is mostly bony, and remains constant in size as muscle development increases or decreases in both the thigh above and calf below. Therefore, as muscle mass increases, the knee appears smaller, while decreased muscle mass gives the appearance of a larger knee. The region of the knee is wider toward the back and narrower in front. Its lateral side is flattened mainly because of the flatness of the lateral condyle of the femur. This lateral side appears slightly depressed owing to

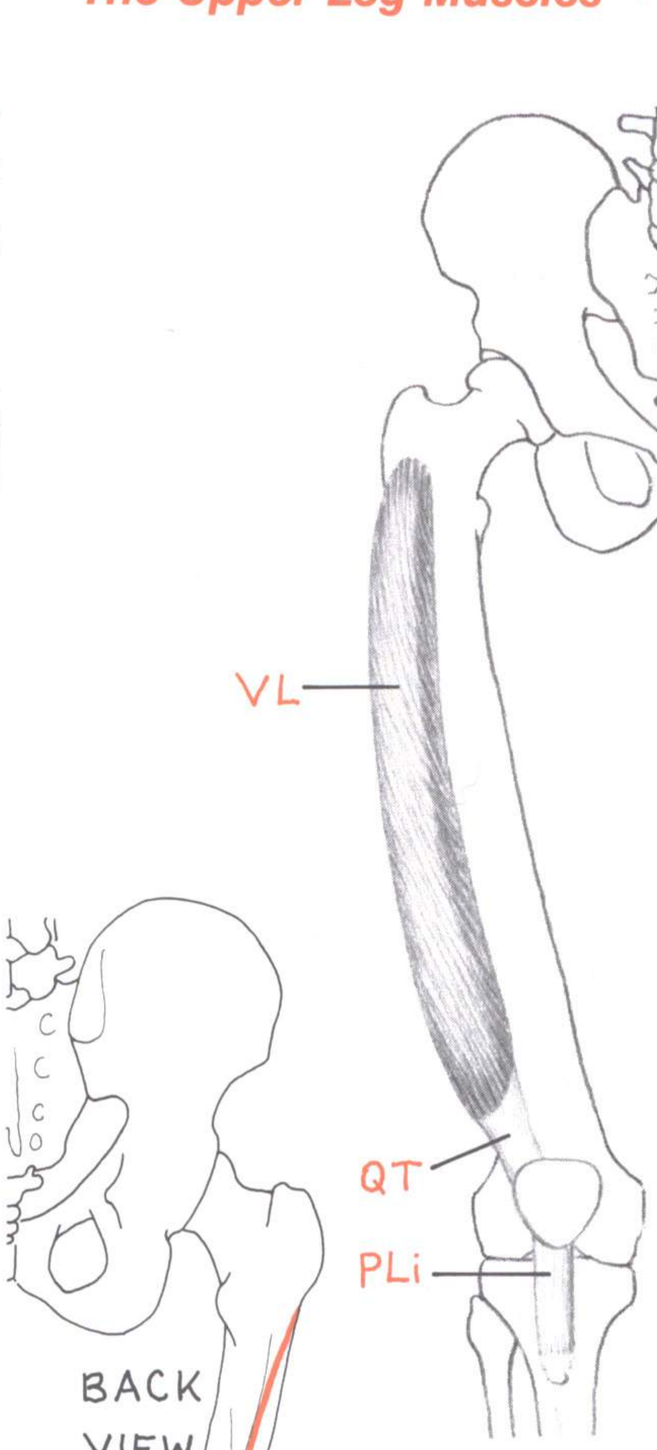
the bulging muscle masses above (outer thigh) and below (outer calf). On the medial side, the form of the vastus medialis continues into the form of the medial condyle of the femur.

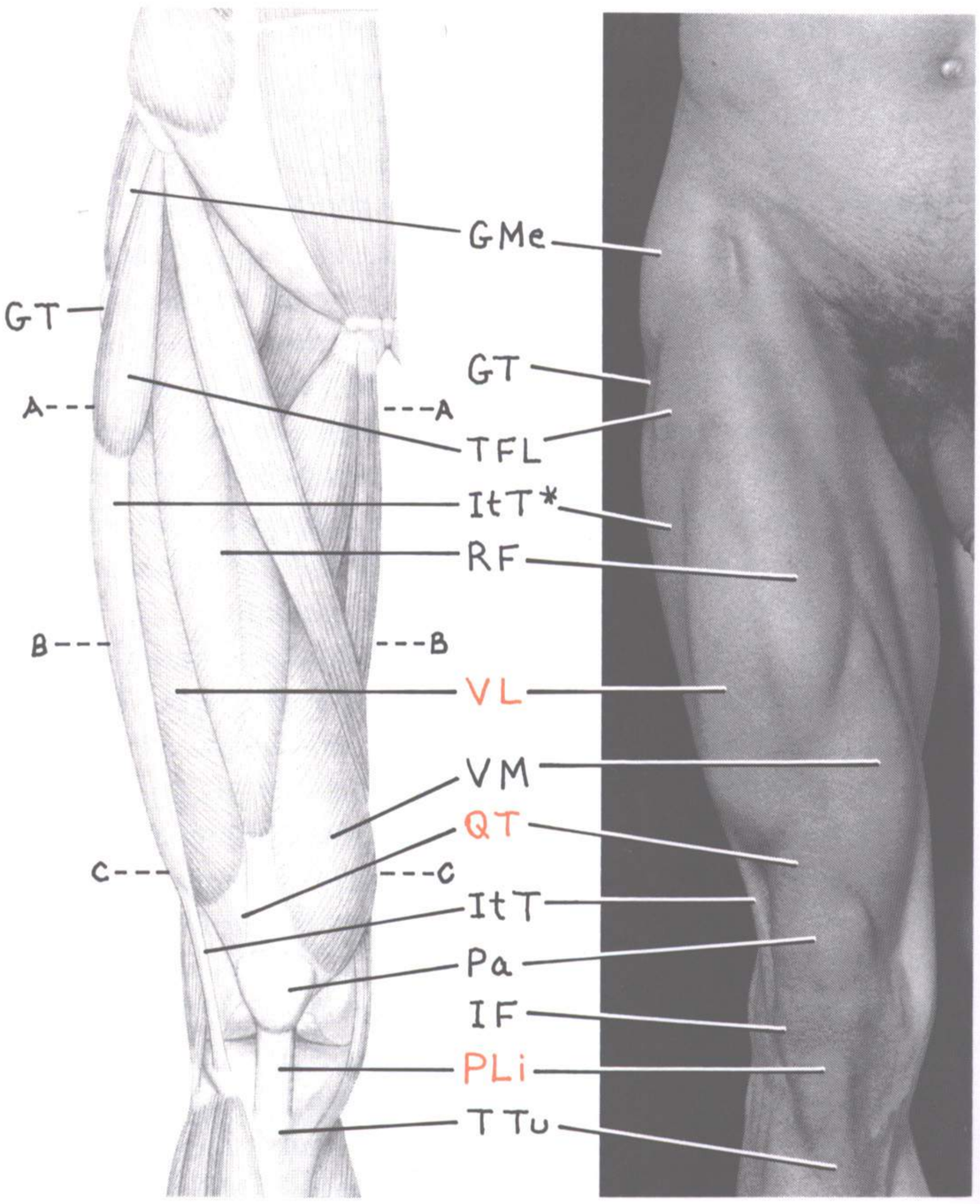
Looking at the thigh in side view, its front profile is long and curved, while its posterior profile is shorter and straighter. By contrast, the back profile of the lower leg is long and curved, while its front profile is shorter and straighter. Viewed from the front, a line drawn downward from the outer surface of the greater trochanter to the high point of the instep (the top of the medial arch of the foot) touches the outer edge of the patella.

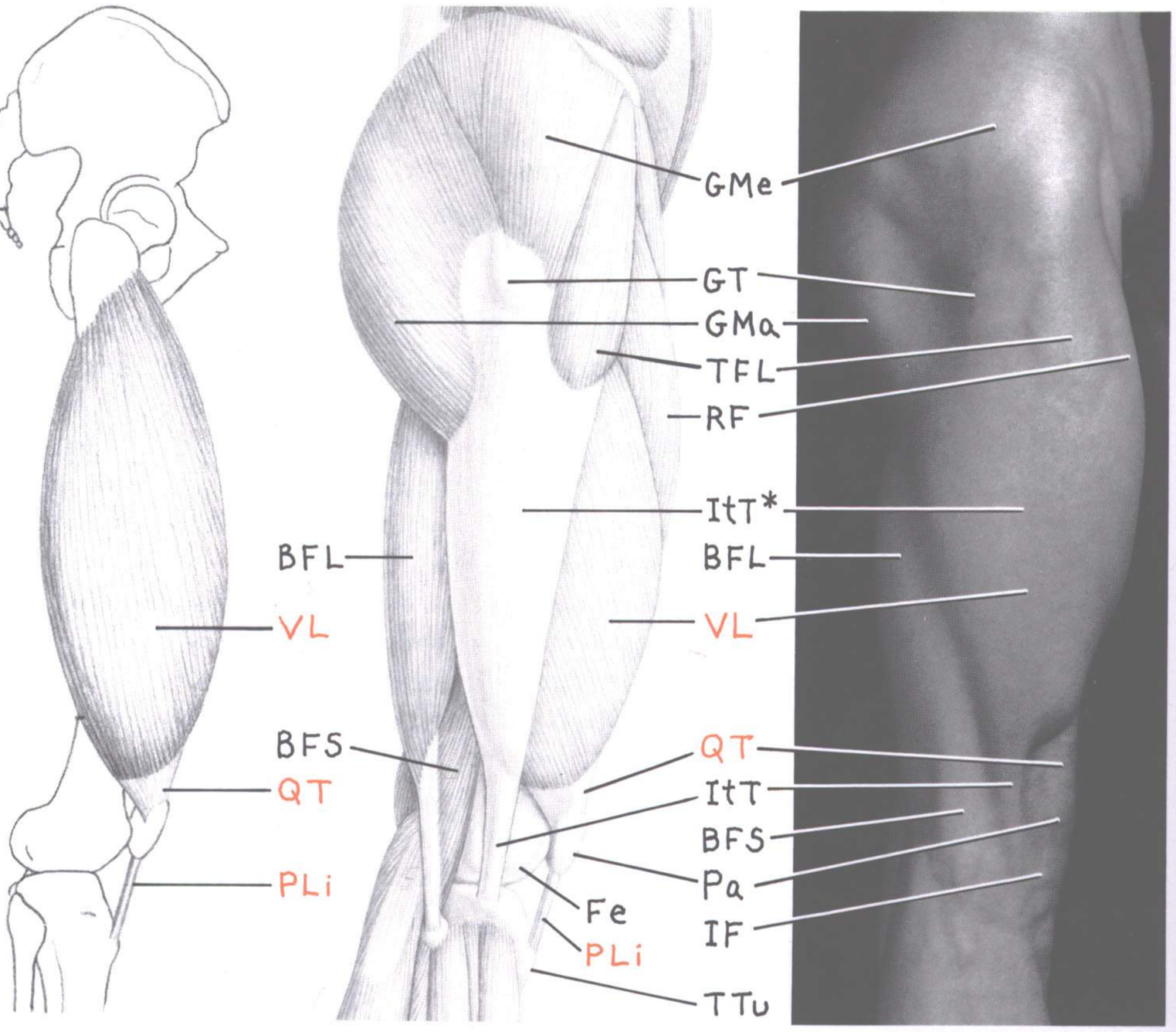
The **femoral triangle** is the triangular hollow located at the upper end of the front of the thigh. It is bordered by the inguinal ligament, adductor longus, iliopsoas, and sartorius. The base of the triangle is at the inguinal ligament; its apex points downward, extending inferiorly deep to the sartorius. The femoral triangle contains major arteries, veins, and nerves of the leg. An ample amount of fat surrounds and protects these structures. In the extended hip, the contents of the femoral triangle are pushed forward and bulge, while in the flexed hip, the femoral triangle becomes a depression, referred to as the "hollow of the thigh."

The **lateral intermuscular septum** of the upper leg is located between the quadriceps and hamstrings. The **medial intermuscular septum** is located between the quadriceps and adductors. Both intermuscular septa begin at the fascia lata surrounding the thigh and pass deeply between the muscles to attach to the linea aspera of the femur. The medial intermuscular septum is developed on the lower portion of the thigh only. The iliotibial tract passes around the posterior surface of the vastus lateralis and becomes the lateral intermuscular septum as it passes deep between the vastus lateralis and biceps femoris.

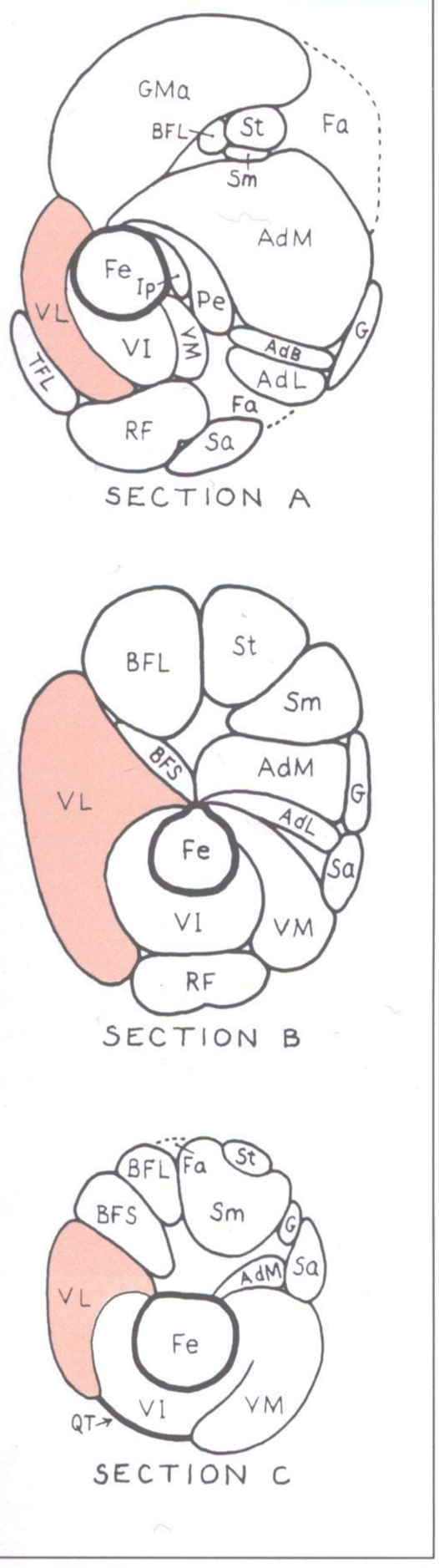








BFL *Biceps femoris—long head* **BFS** *Biceps femoris—short head* **Fe** *Femur* **GMa** *Gluteus maximus*
GMe *Gluteus medius* **GT** *Greater trochanter* **IF** *Infrapatellar fat pad* **ItT** *Iliotibial tract* **Pa** *Patella*
PLi *Patellar ligament* **QT** *Quadriceps tendon* **RF** *Rectus femoris* **TFL** *Tensor fascia lata*
TTu *Tibial tuberosity* **VI** *Vastus intermedius* **VL** *Vastus lateralis* **VM** *Vastus medialis*
* *On vastus lateralis*



Vastus Lateralis
(Vastus Externus)

ORIGIN A line that begins on the front of the greater trochanter of the femur, curves around the outside of the femur below the trochanter, reaches the linea aspera on the midline of the back of the femur, and descends along its lateral lip to end halfway down, or lower, on the bone. It also originates from the lateral intermuscular septum between the vastus lateralis and short head of the biceps femoris.

INSERTION By the quadriceps tendon into the lateral border and upper outer corner of the patella. It ultimately inserts into the tibial tuberosity via the patellar ligament.

ACTION Extends the lower leg at the knee joint (lifts the body from a squatting position by extending the knee joint or lowers the body against the pull of gravity by controlling the rate of knee flexion).

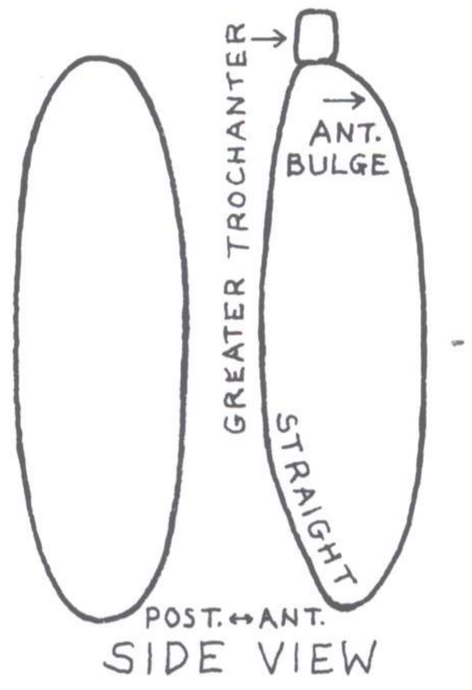
STRUCTURE Largest of the quadriceps muscles, the vastus lateralis occupies the lateral side of the thigh, yet also extends partially around to both the front and back of the thigh. Note that the line of origin begins on the *front* surface at the *top* of the femur, and it is here where its muscle mass begins to bulge forward. The upper portion of the muscle, lying on the *outer* surface of the femur just below the greater trochanter, begins quite thin, but thickens as it descends.

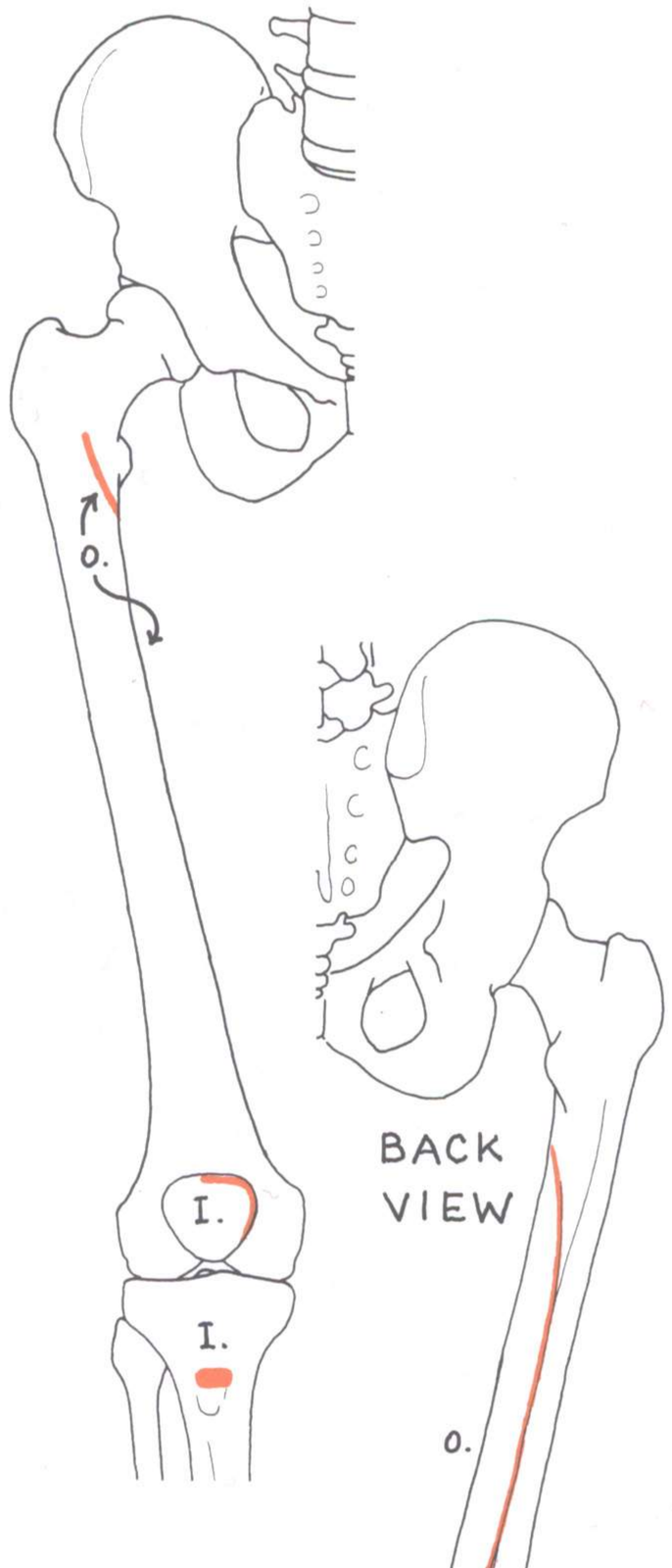
The lower portion of the posterior edge (in side view) may be straight. Its outer surface is somewhat flattened. The muscle mass of the vastus lateralis ends inferiorly a couple of inches above the top of the patella, at a level lower than the bottom of the rectus femoris and higher than the bottom of the vastus medialis. The muscle fibers do not reach the patella, nor do they cover the lateral condyle of the femur. When the knee is flexed, the vastus lateralis is stretched and becomes thinner.

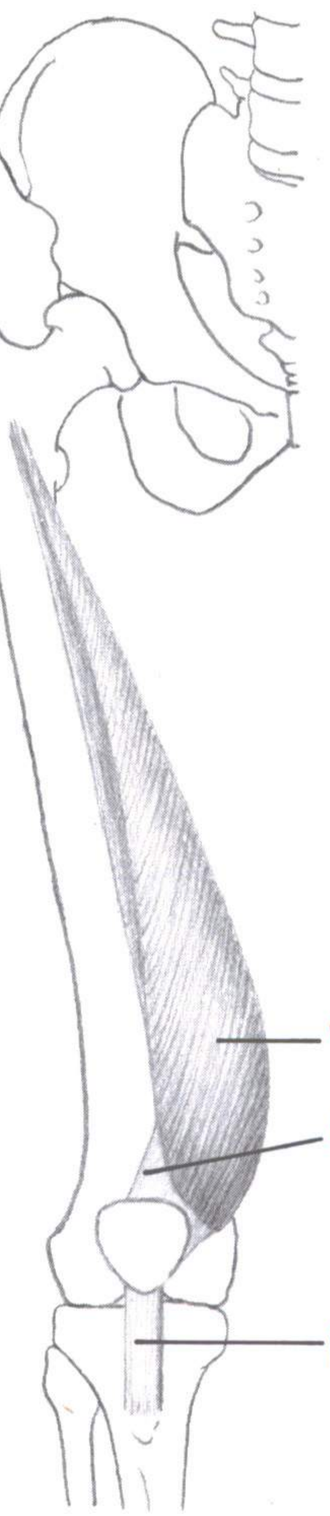
When the iliotibial tract, which lies on top of the vastus lateralis, is pulled taut, one or more longitudinal furrows, elongated flattened planes, and/or raised ridges appear on the outer surface of the belly of the vastus lateralis. Various patterns may emerge. Because the tensor fascia lata and gluteus maximus insert into the superior end of the iliotibial tract, and because the tract ultimately inserts into the lateral condyle of the tibia, the tension furrows and flattenings are usually directed from various parts of these contracting muscles above to the insertion point below.

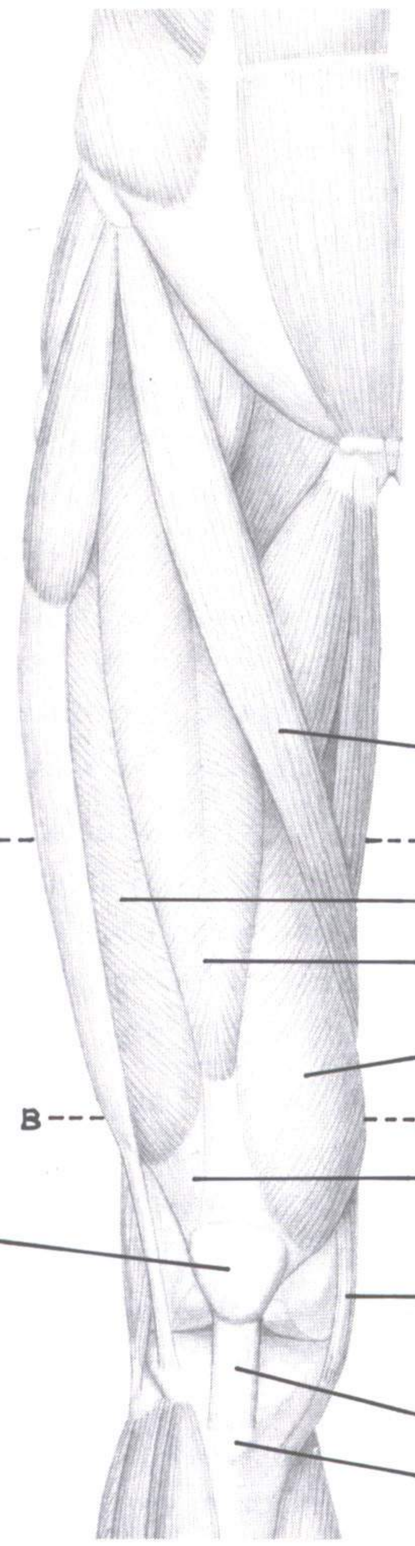
An oblique furrow directed downward and forward may develop from the bottom of the tensor fascia lata. Because it is not directed toward the outside of the knee, it is not caused by a tensed iliotibial tract, but rather by a portion of the fascia of the leg anterior to the actual tract. At the outside of the knee, the iliotibial tract is continued downward from the *posterior* edge of the vastus lateralis. The tract creates its own elongated surface form after it leaves the surface of the vastus lateralis.

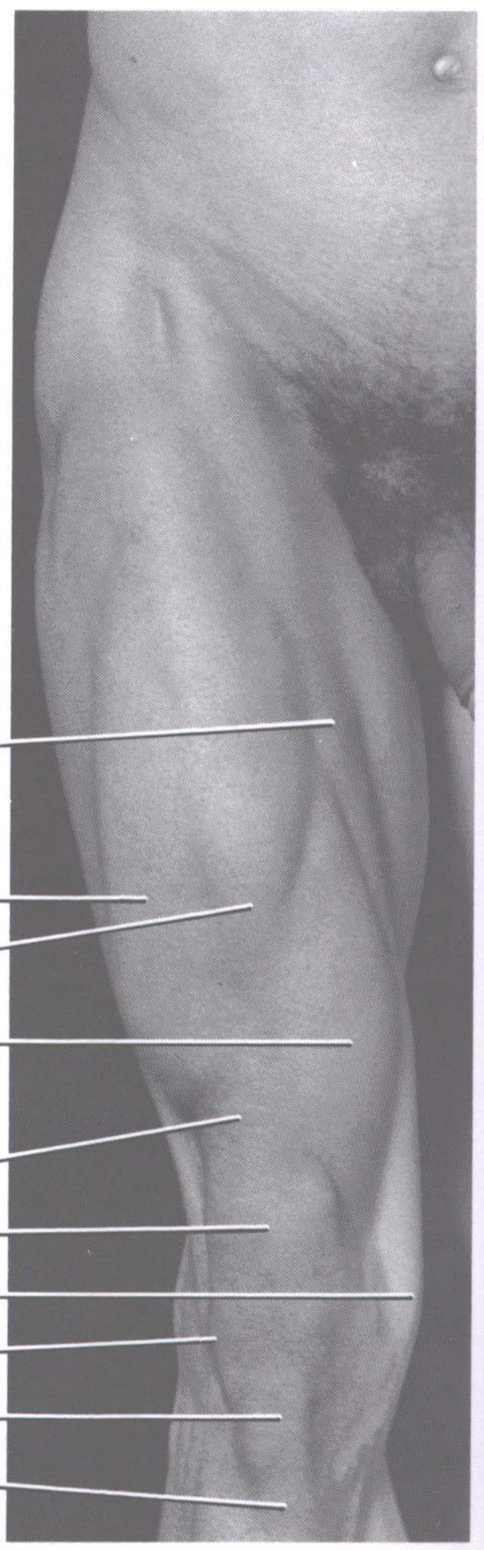
The **vastus intermedius** is an extensive muscle that lies deep to all the other quadriceps bellies, adding muscular fullness under them.

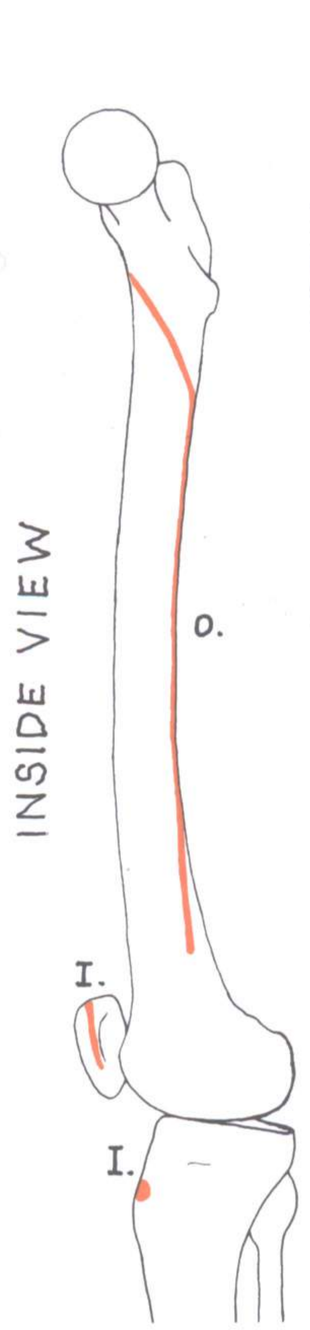


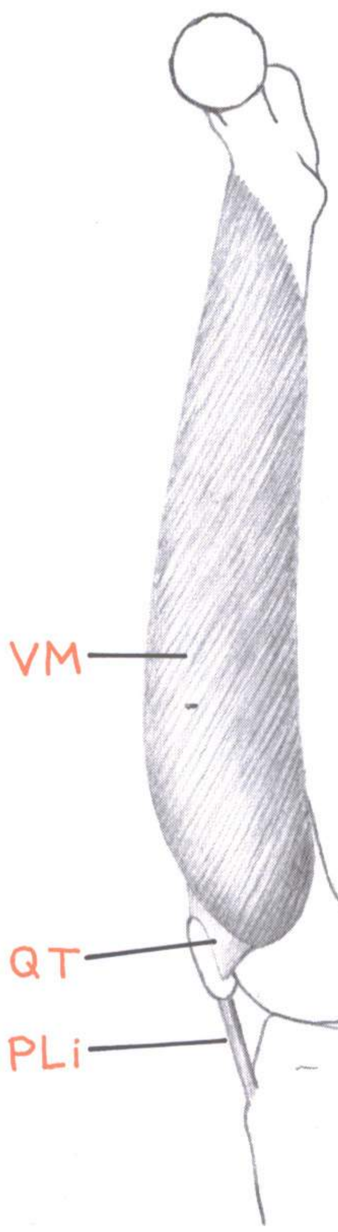


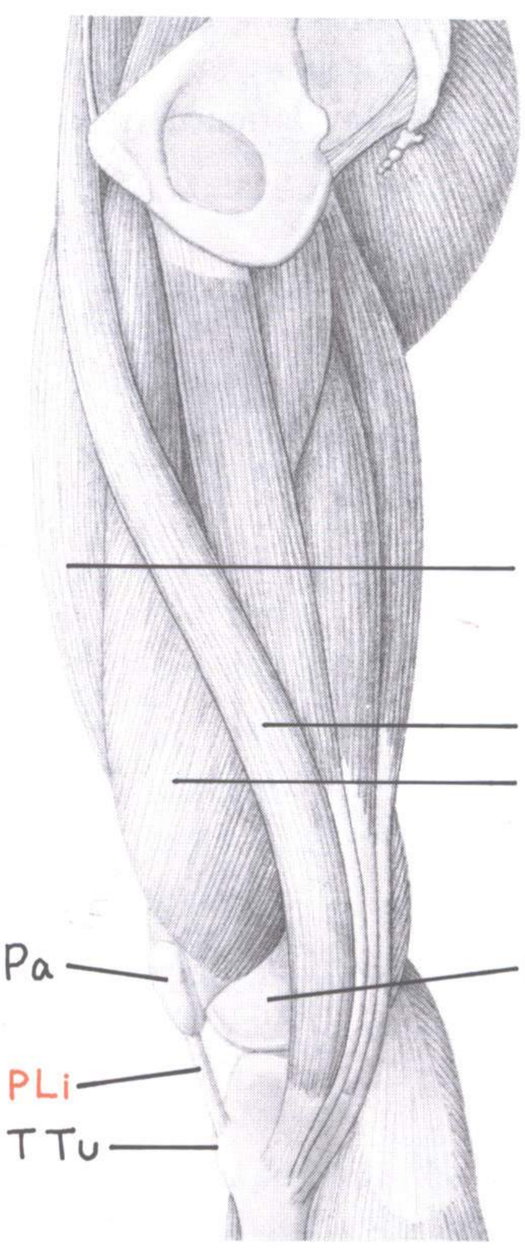


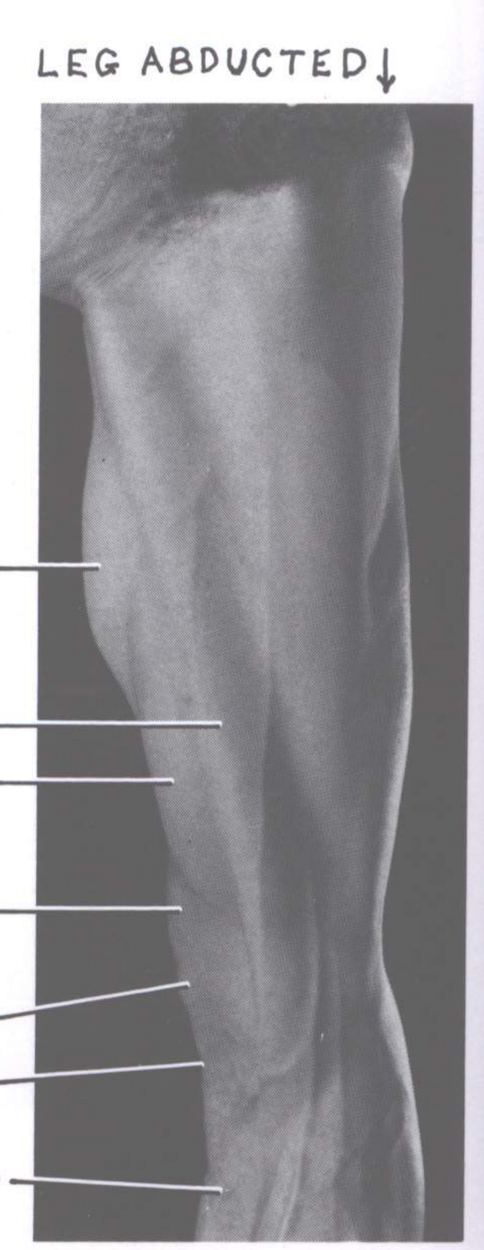




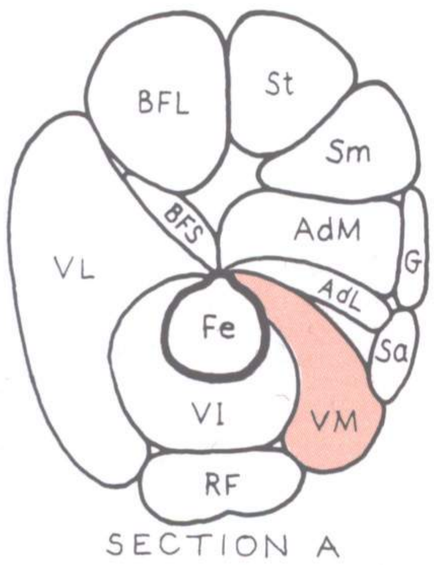




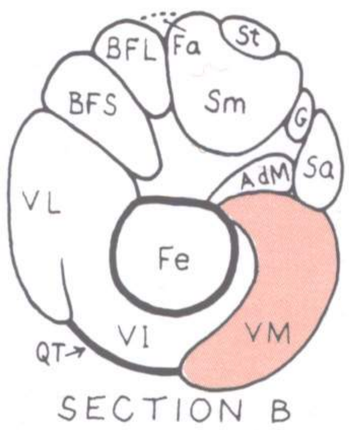




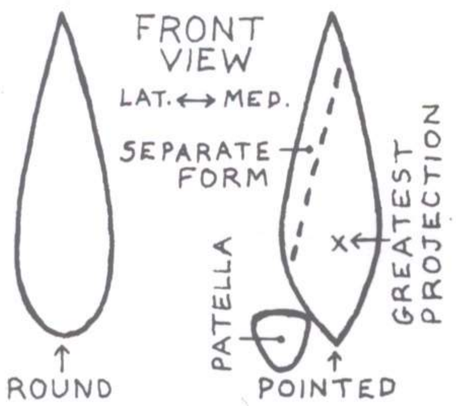
AdL *Adductor longus* **AdM** *Adductor magnus* **Fe** *Femur* **IF** *Infrapatellar fat pad* **Pa** *Patella*
PLi *Patellar ligament* **QT** *Quadriceps tendon* **RF** *Rectus femoris* **Sa** *Sartorius* **TTu** *Tibial tuberosity*
VI *Vastus intermedius* **VL** *Vastus lateralis* **VM** *Vastus medialis*

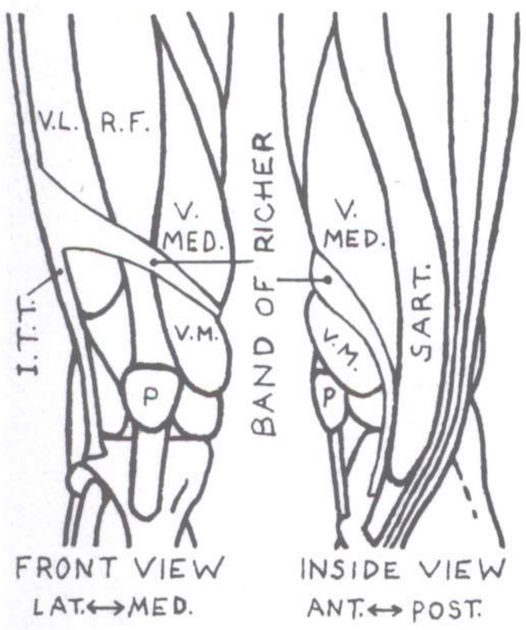


SECTION A



SECTION B





Vastus Medialis (Vastus Internus)

ORIGIN A line beginning on the *front* of the femur at the level of the lesser trochanter which curves around the inside of the shaft of the bone to reach the linea aspera on the back of the femur. It descends along its medial lip, then veers medially into the upper part of the medial supracondylar line of the femur. The vastus medialis also originates from the tendons of the adductor longus and magnus and from the medial intermuscular septum.

INSERTION By the quadriceps tendon into the medial border of the patella and by muscle fibers directly into the patella's upper inner corner. The vastus medialis ultimately inserts into the tibial tuberosity via the patellar ligament.

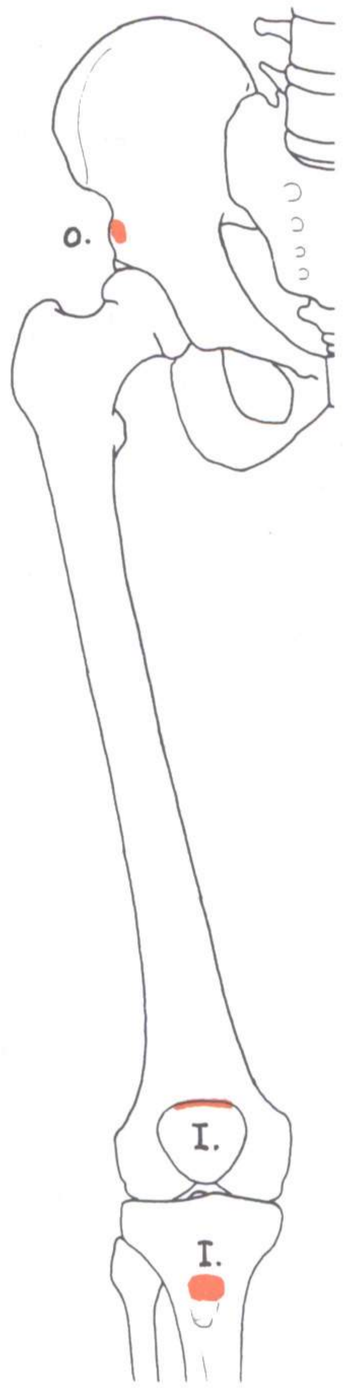
ACTION Extends the leg at the knee joint.

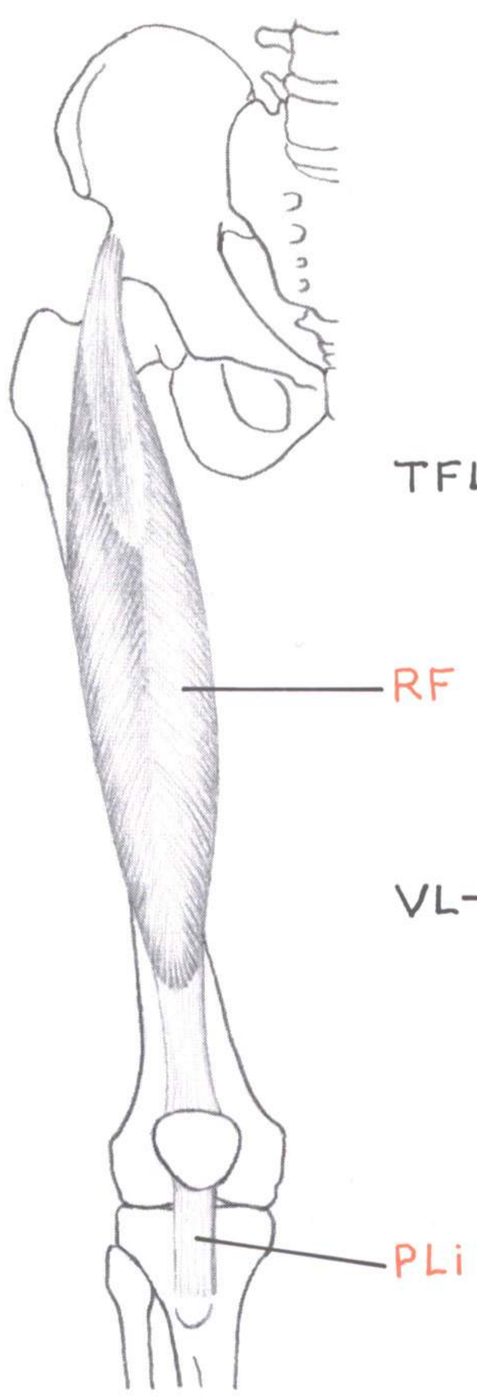
Functionally, the vastus medialis can be divided into two portions. The upper portion, or **vastus medialis longus,** extends the knee. The lower portion, or **vastus medialis oblique,** does not extend the knee, but rather pulls the patella medially and posteriorly to counteract the lateral pull of the vastus lateralis. This keeps the patella tracking in its groove between the femoral condyles.

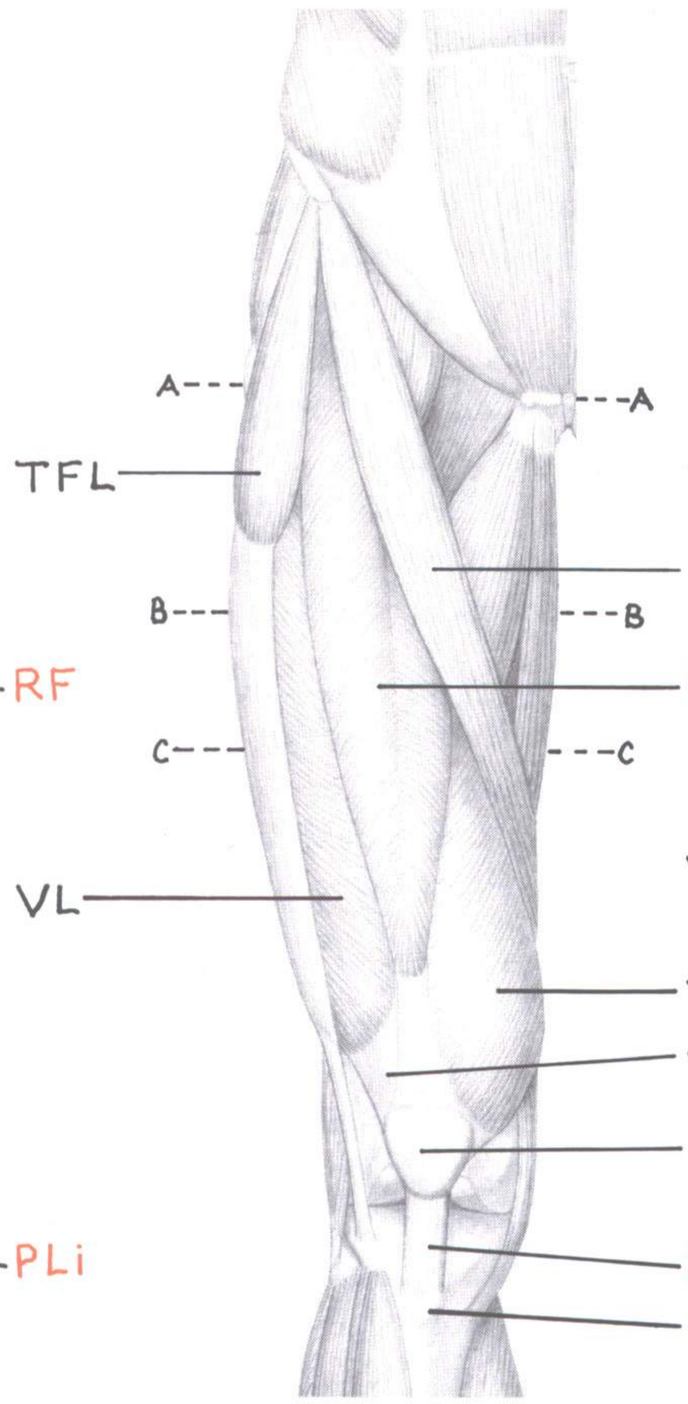
STRUCTURE Lowest of the quadriceps muscles, the vastus medialis is a bulging teardrop form located on the inner front corner of the lower two-thirds of the thigh. The very bottom of its form ends on the *inside* of the knee (either rounded or pointed), at the level of the *middle* of the patella. Its form touches the upper inner corner of the patella, where an oblique skin fold appears, especially when the muscle is tensed.

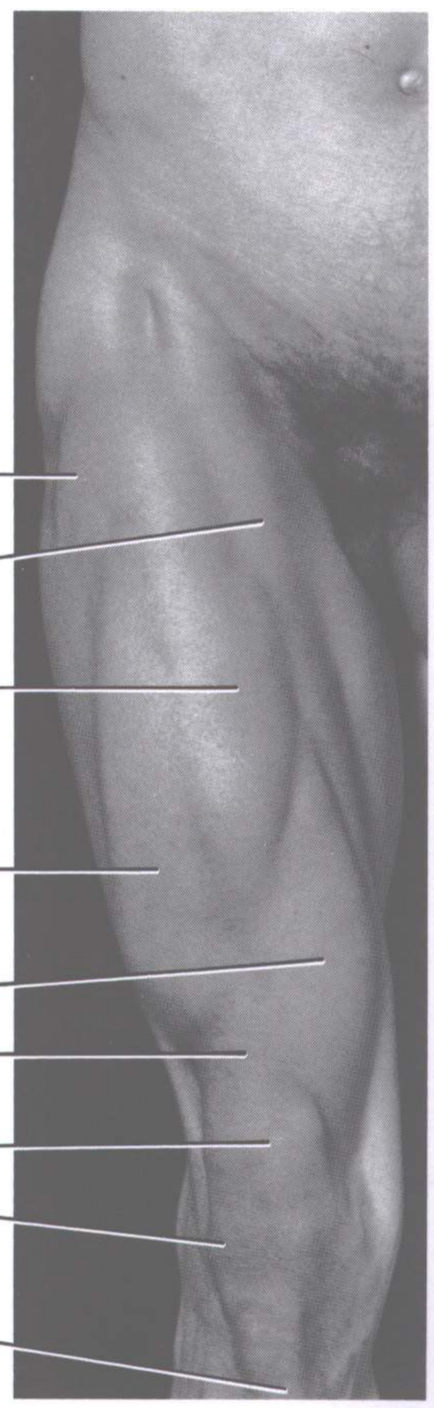
The form of this muscle is thin at the very top of the shaft of the femur (deep to other muscles) and gets thicker as it descends. When the lower leg is flexed at the knee joint, the medial side of the bent knee appears smooth and rounded, because the fleshy vastus medialis becomes stretched over and blankets the medial condyle of the femur. The muscle, however, does not completely cover the medial condyle, regardless of knee position. In the flexed knee position, a hollow may appear posterior to the vastus medialis, located between the vastus and sartorius. A portion of the vastus medialis lying adjacent and parallel to the rectus femoris occasionally shows up as a separate, elongated, thin form and is sometimes confused with the rectus femoris.

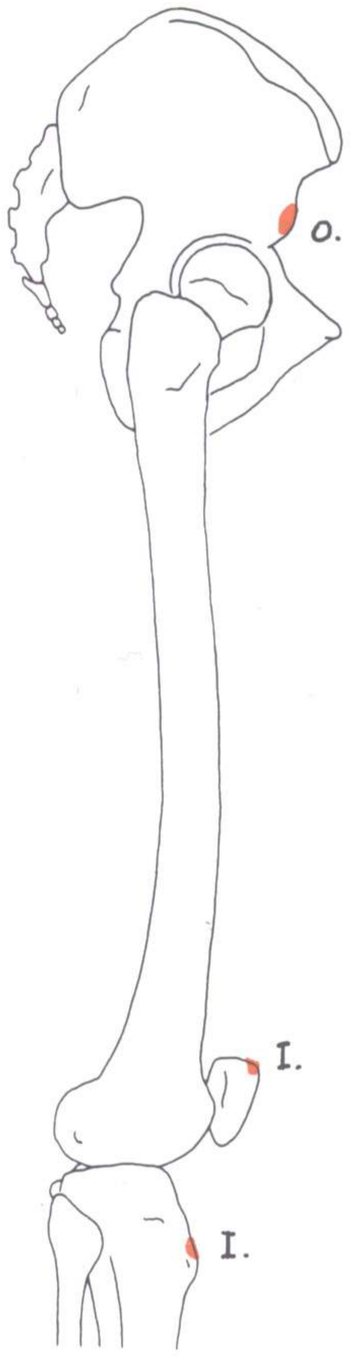
The **band of Richer** is a thickening of the deep fascia of the leg into a nonelastic narrow band. It descends obliquely from the outside to the inside of the leg across the front of the lower portion of the thigh and produces an oblique furrow across the soft muscular forms deep to it. The band technically begins at the iliotibial tract on the outside of the leg, three-fourths of the way down the thigh, and ends on the inside of the knee, inserting as far down as the medial surface of the shaft of the tibia. Most noticeable in the straight leg across the lower end of the vastus medialis and sometimes across the vastus lateralis (it does not affect the rectus femoris), the furrow becomes pronounced when the quadriceps is relaxed, and usually, but not always, disappears when it is tensed. The relaxed vastus medialis can bulge considerably below the band. On the inside of the knee (in front of the sartorius), the band of Richer can sometimes produce a fine, vertical, cordlike raised ridge as its medial end leaves the form of the vastus medialis to insert into the tibia.

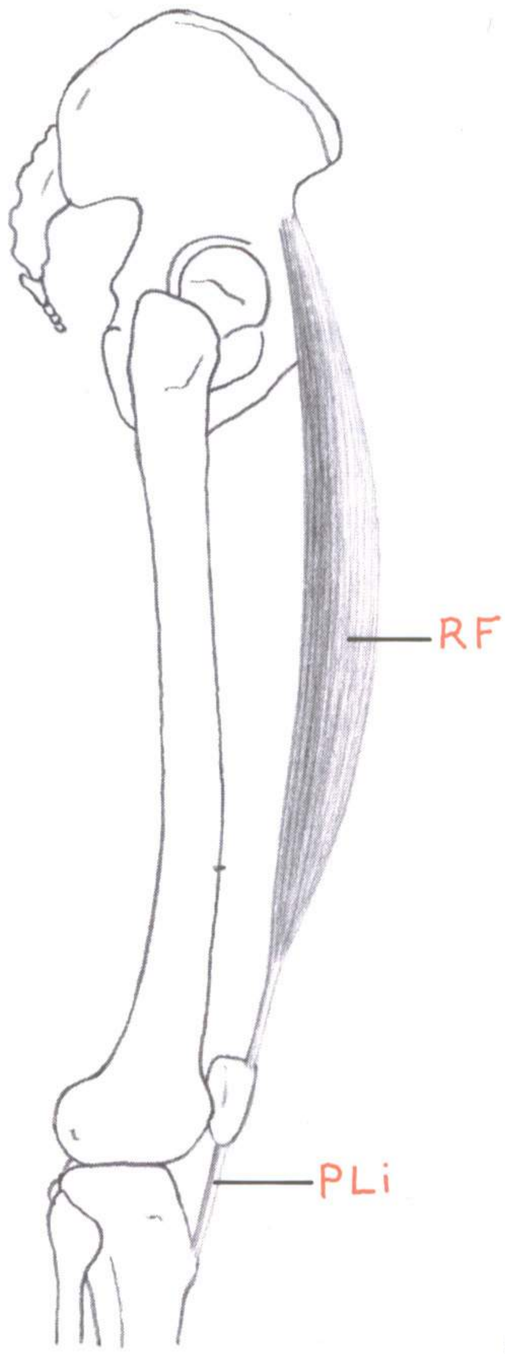


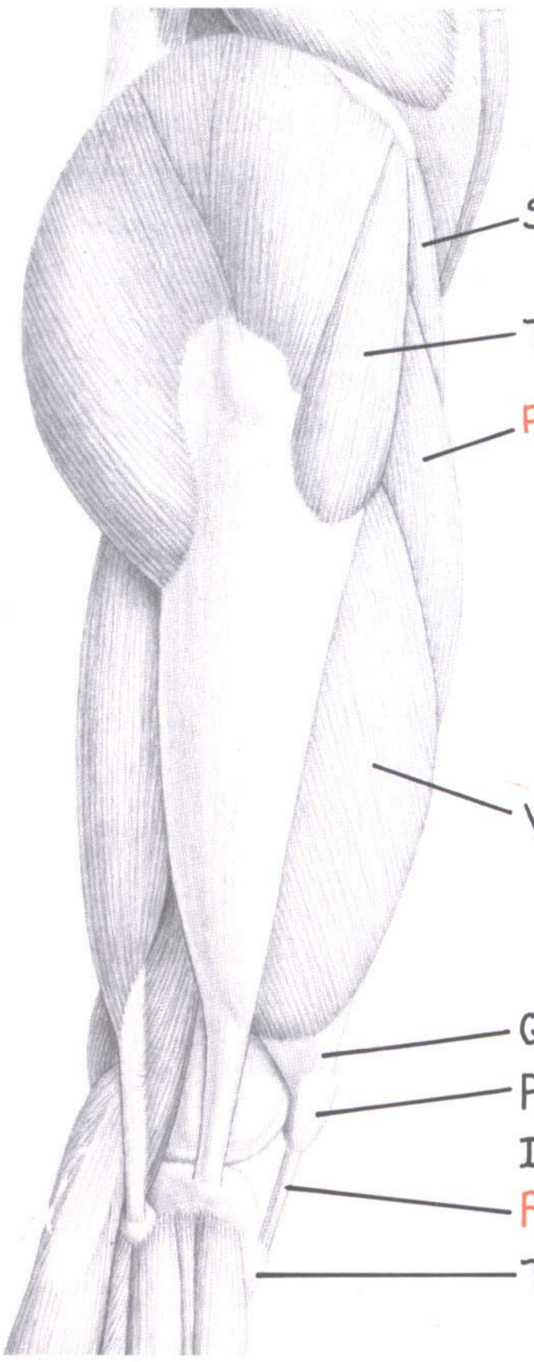


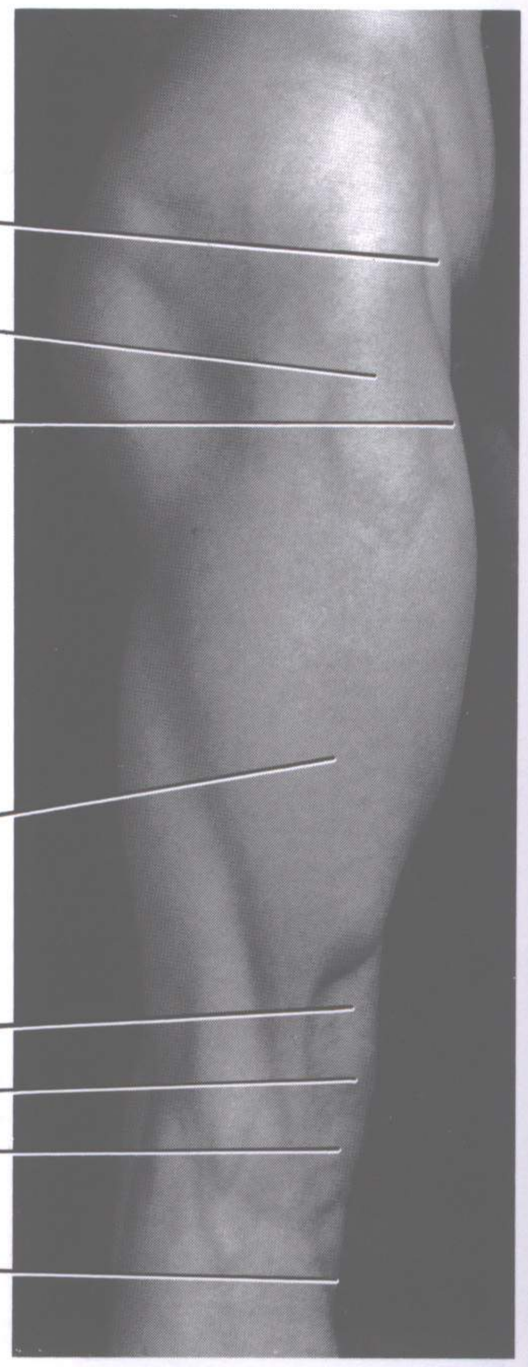




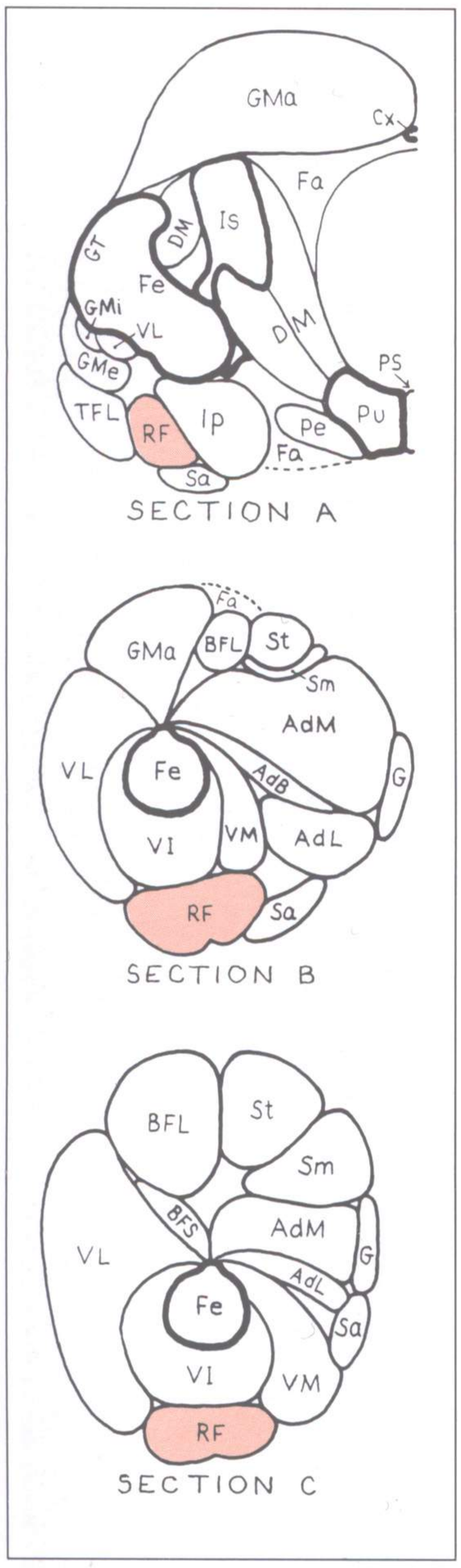








Fe *Femur* **IF** *Infrapatellar fat pad* **Ip** *Iliopsoas* **Pa** *Patella* **PLi** *Patellar ligament*
QT *Quadriceps tendon* **RF** *Rectus femoris* **Sa** *Sartorius* **TFL** *Tensor fascia lata* **TTu** *Tibial tuberosity*
VI *Vastus intermedius* **VL** *Vastus lateralis* **VM** *Vastus medialis*



Rectus Femoris

ORIGIN Anterior inferior iliac spine. (This is the origin of the *straight tendon*. The *reflected tendon,* arising from the top of the acetabulum, is small and deep, with no effect on surface form.)

INSERTION Top of the patella; therefore, it ultimately inserts into the tibial tuberosity via the patellar ligament.

ACTION Extends the leg at the knee joint; flexes the thigh at the hip joint.

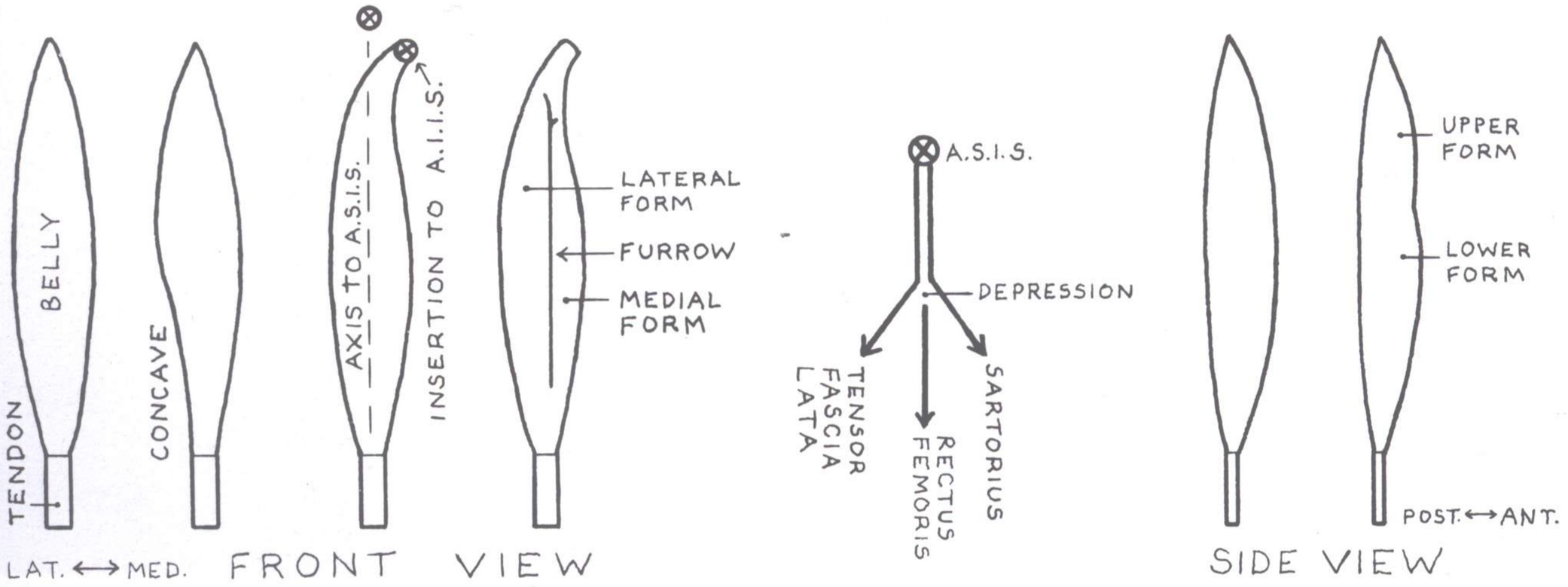
STRUCTURE The rectus femoris is one of the four bellies of the quadriceps muscle group. It is the only two-joint muscle in this group, crossing both knee and hip joints. Its belly is long, flattened, and fusiform, sometimes showing a furrow down the middle of its upper half in well-developed individuals. The furrow is caused by the bipennate arrangement of the muscle fibers inserting into its median tendon and therefore divides the belly into lateral and medial forms. The lateral form is larger, higher, and more prominent than the medial form. The lower lateral edge of the belly can be either convex or concave (looking at in front view).

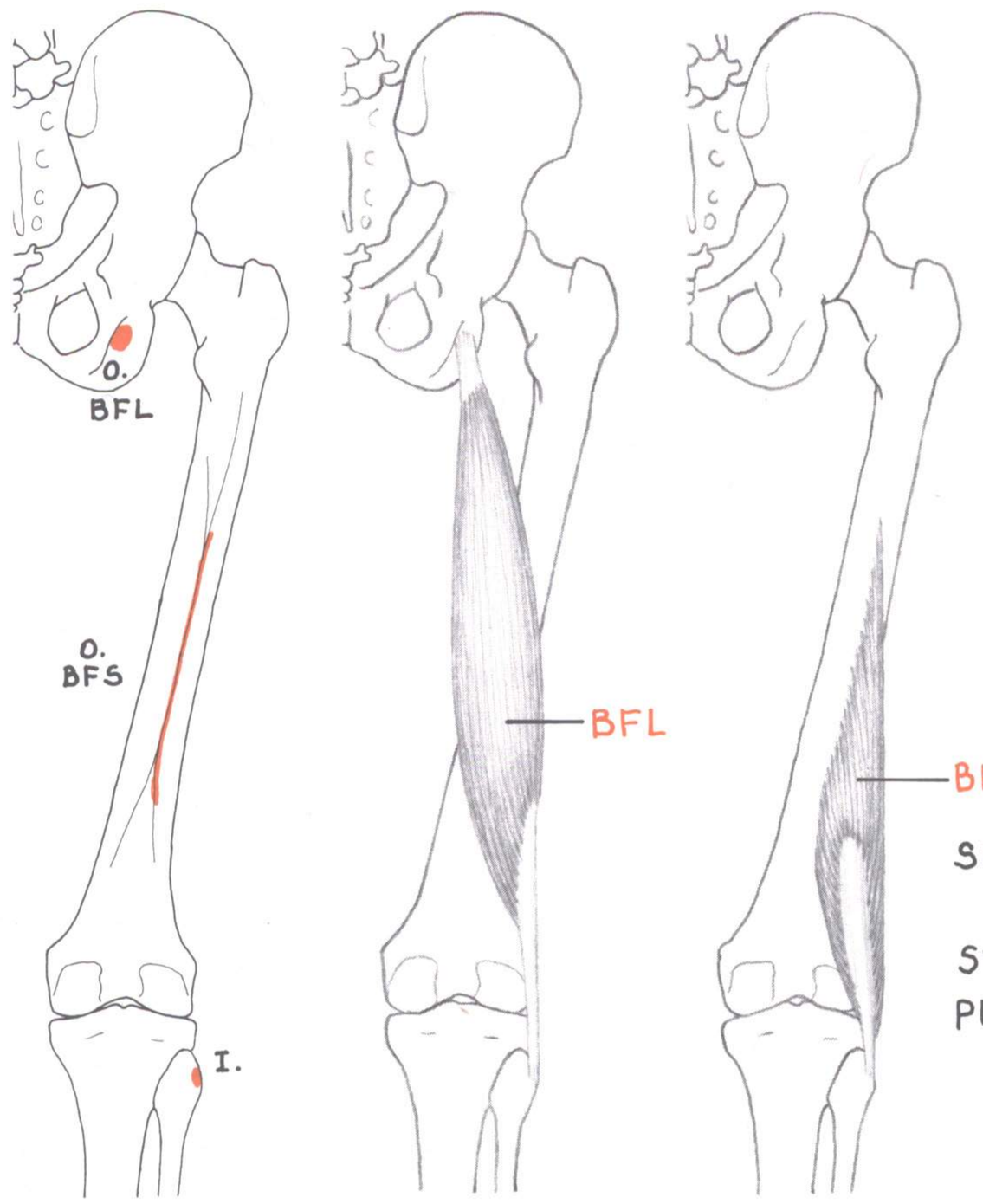
The inferior end of the belly can be quite tapered and pointed, and also slightly depressed, as the vasti muscles bulge on either side of it. The ribbonlike tendon of insertion attaches to the top of the patella. It lies on, yet is independent of, the quadriceps tendon, and may be seen during partial knee flexion when the quadriceps is contracted.

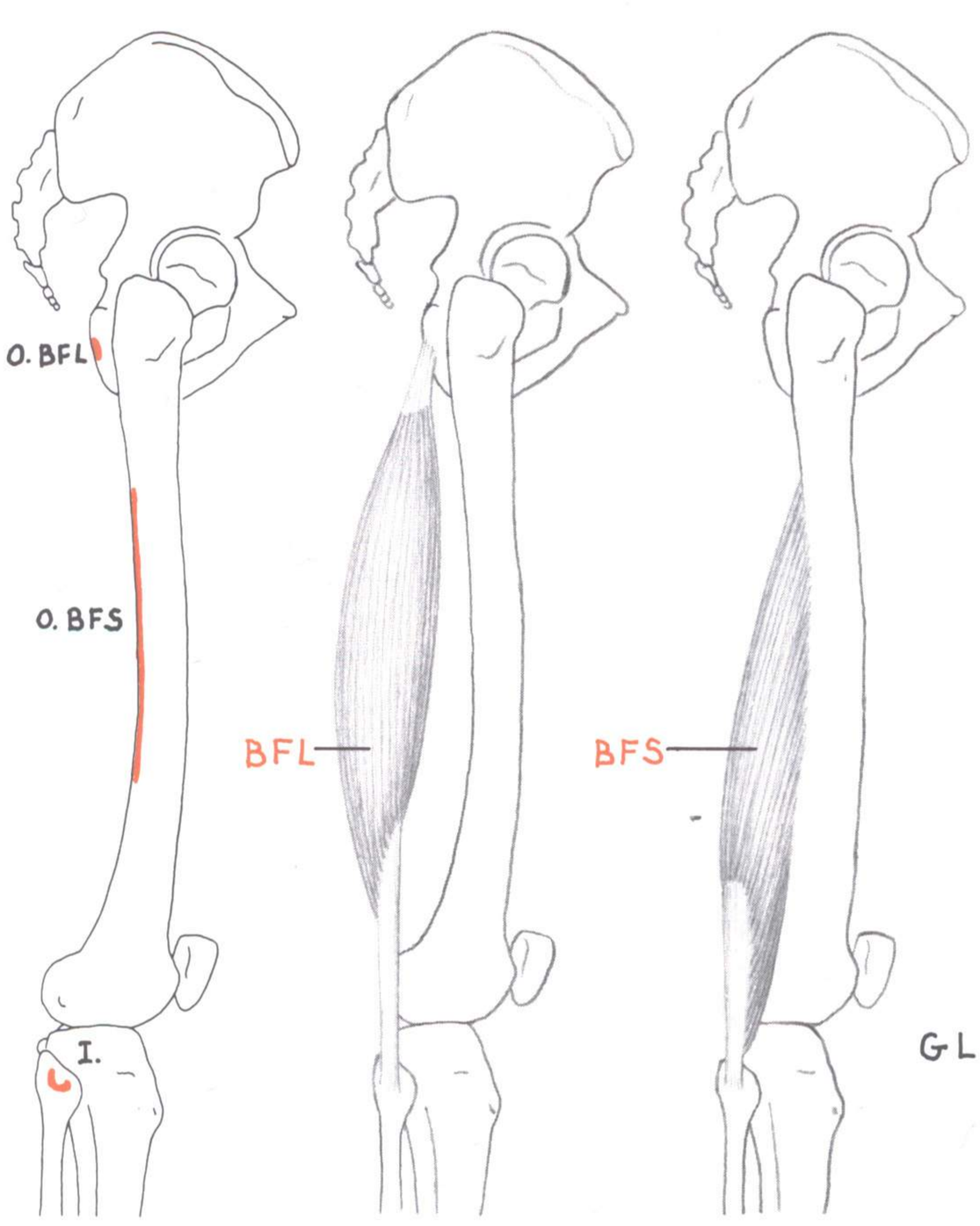
The lower end of the muscular belly of the rectus femoris ends approximately a hand's breadth above the top of the patella. It ends highest of all the quadriceps bellies; the vastus medialis ends the lowest, and the vastus lateralis ends at a level between them.

A depression is present three finger widths below the anterior superior iliac spine of the pelvis; it is especially evident when the thigh is flexed at the hip joint. This depression marks the point where the rectus femoris dives deep between the sartorius and tensor fascia lata, toward its insertion on the anterior inferior iliac spine. The upper end of the rectus femoris is covered by the sartorius. When looking at the figure from the side view with the thigh flexed (as in the sitting position), the top (anterior) surface of the thigh is directed toward the anterior *inferior* iliac spine, the origin of the rectus femoris, not the anterior *superior* iliac spine.

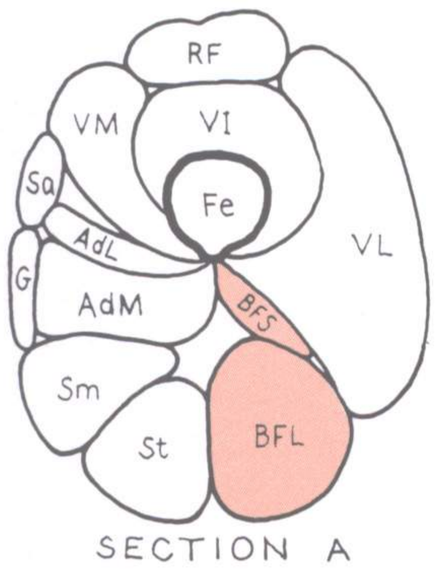
The rectus femoris sits in a muscular groove on the front of the thigh. The vastus intermedius creates the floor of the groove, and the vasti medialis and lateralis form the sides (see cross section).







AdM *Adductor magnus* **BFL** *Biceps femoris—long head* **BFS** *Biceps femoris—short head* **Fa** *Fat* **Fe** *Femur* **GL** *Gastrocnemius—lateral head* **GMa** *Gluteus maximus* **HF** *Head of fibula* **ItT** *Iliotibial tract* **Pl** *Plantaris* **Sm** *Semimembranosus* **So** *Soleus* **St** *Semitendinosus* **T** *Tibia* **Tn** *Tendon* **VL** *Vastus lateralis*



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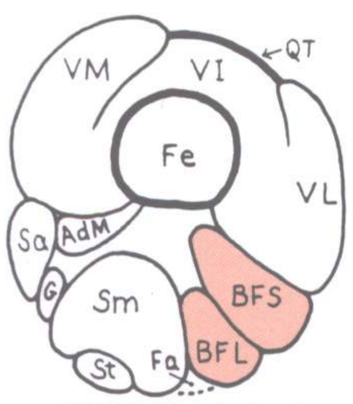

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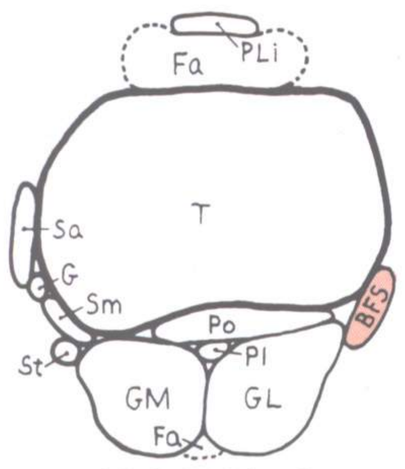


SECTION C

Biceps Femoris

ORIGIN *Long head:* Ischial tuberosity of the pelvis and the adjacent lower part of the sacrotuberous ligament. *Short head:* A line on the middle third of the back of the femur.

INSERTION Outer surface of the head of the fibula (with a tendinous slip to the lateral condyle of the tibia).

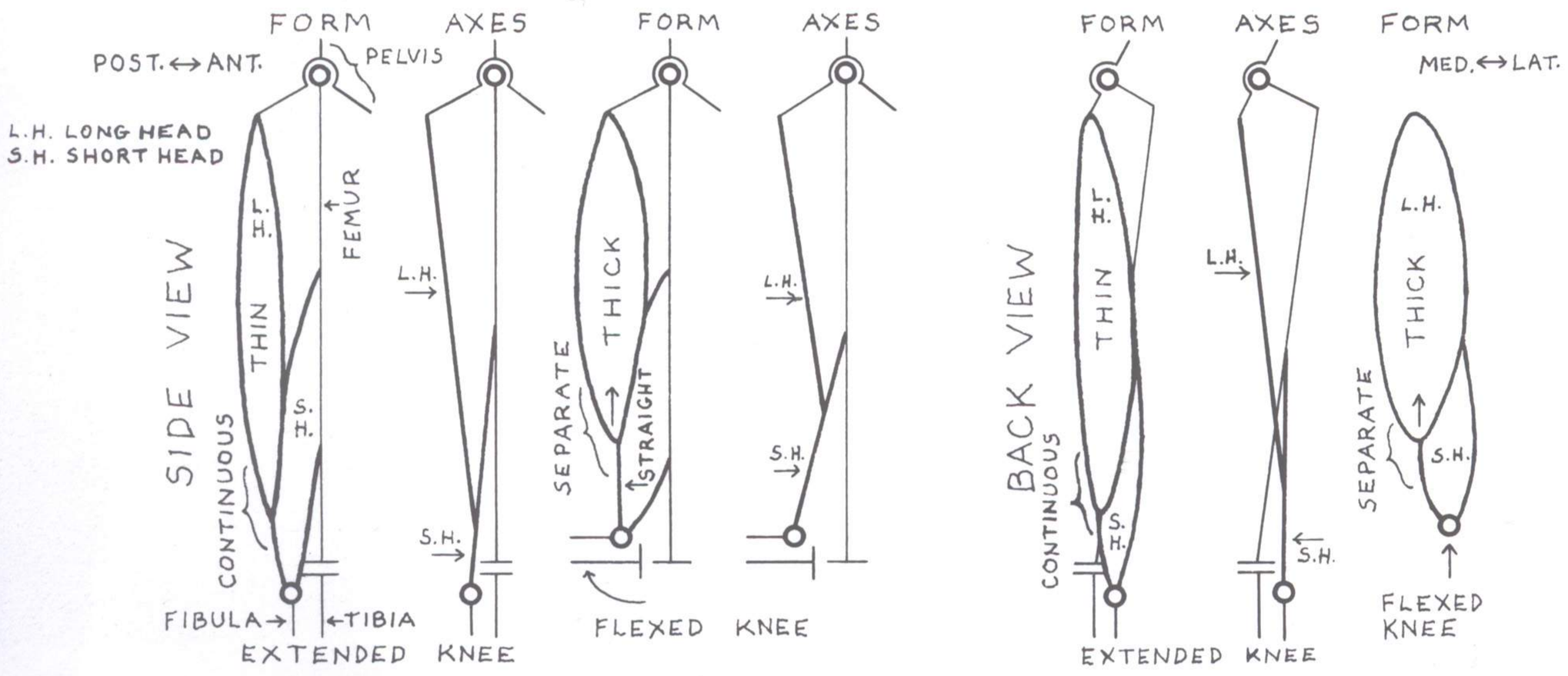
ACTION Both heads flex the lower leg at the knee joint and then rotate the tibia laterally; the long head also extends and assists in lateral rotation of the thigh at the hip joint. The long head is a two-joint muscle, while the short head is a one-joint muscle.

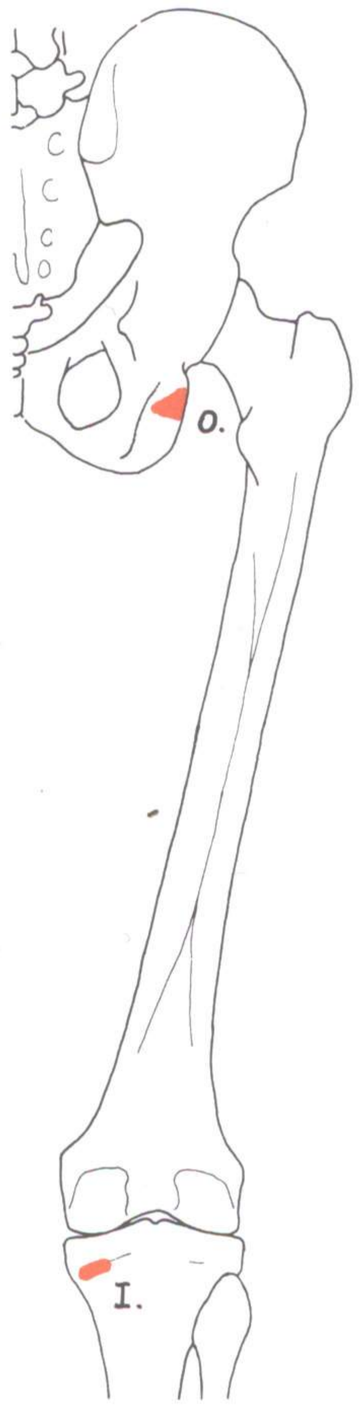
STRUCTURE The biceps femoris is comprised of two heads, a long and a short, and their single tendon of insertion. This **common tendon,** located on the outer back corner of the knee and shared by both heads, begins aponeurotically on the lower posterior surface of the belly of the long head, leaves the belly, and then tapers into a strong, wide, flat tendon. The tendon descends over the posterior portion of the short head. The fibers of the short head insert into the deep aspect of this tendon all the way down to the head of the fibula.

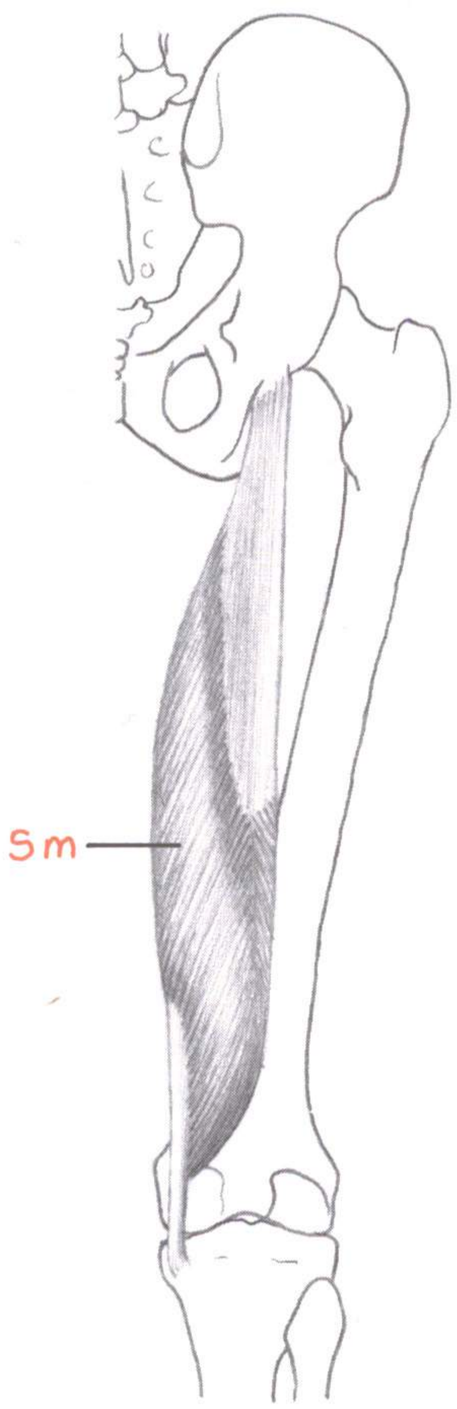
In the straight leg, the two heads generally produce a single elongated fusiform shape (barely separable from the semitendinosus, but very distinct from the vastus lateralis), and the tendon is not seen. The two heads may, however, be discernible in the straight leg. The fleshy muscular form of the short head eventually passes downward on the *outside* of the knee to the head of the fibula, sometimes appearing quite wide and bulging prominently. Its form may end a short distance above the head of the fibula.

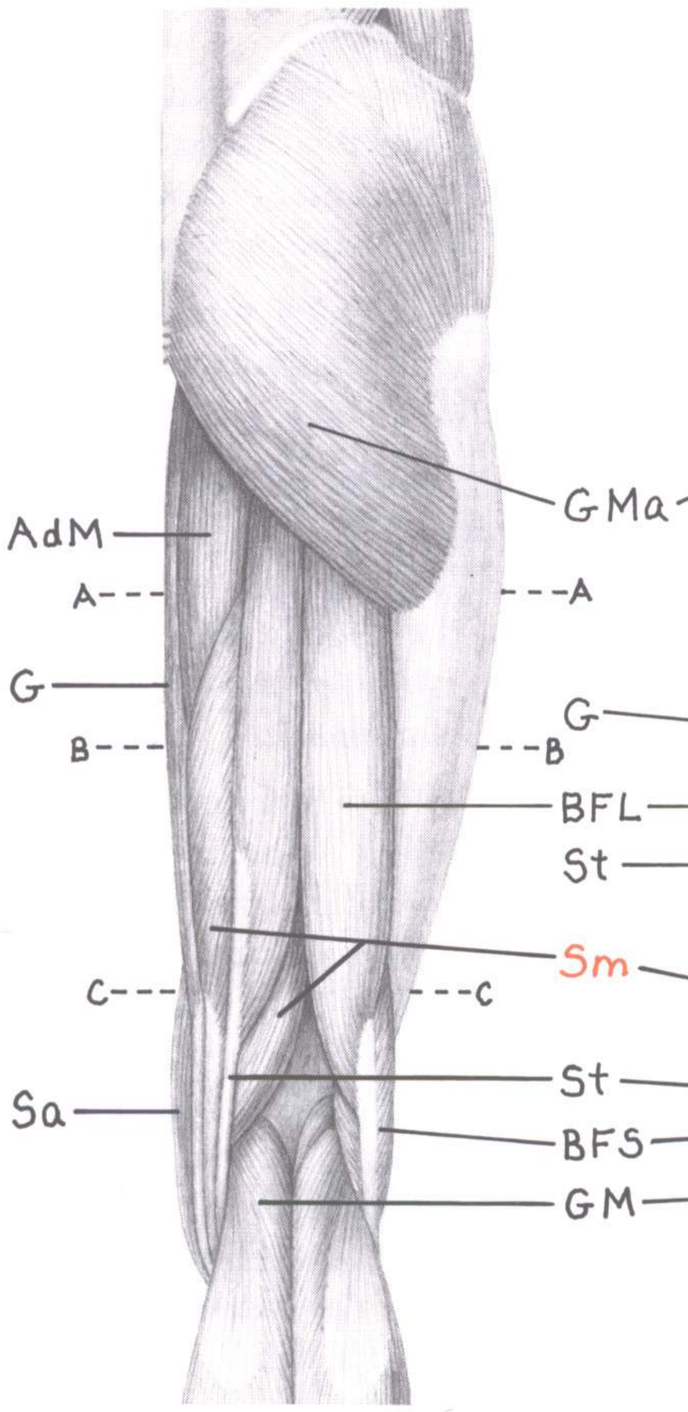
In the extended knee, the medial (posterior) edge of the common tendon often produces a vertical furrow on the lateral side of the back of the knee, defining the lateral limit of the popliteal bulge.

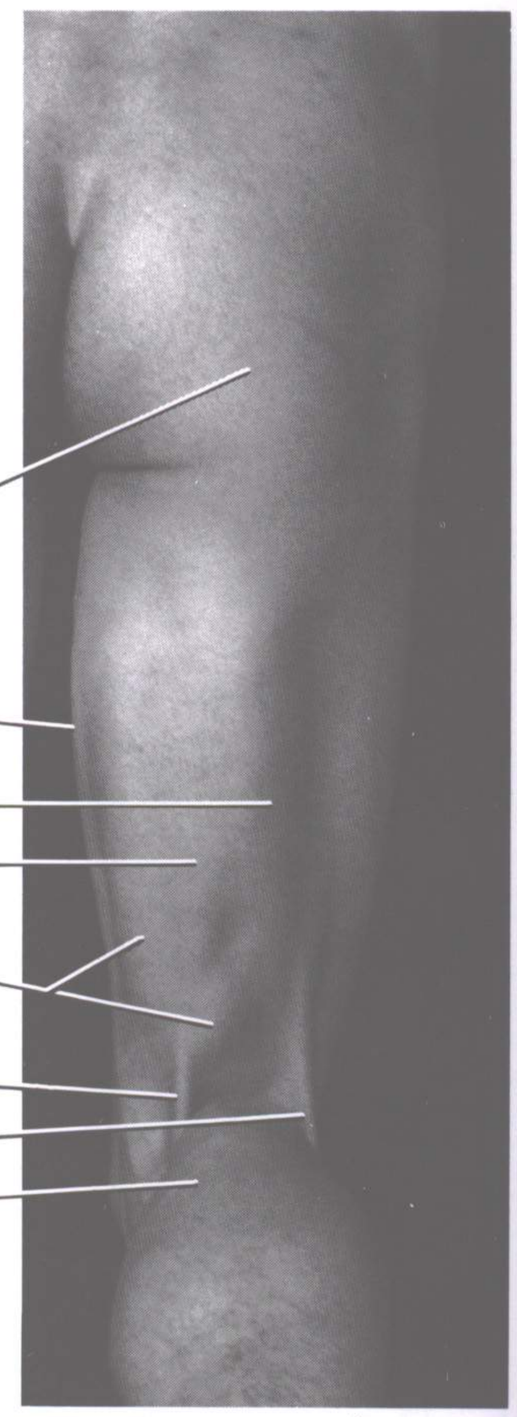
The lower end of the belly of the long head ends approximately three-fourths of the way down the thigh. Its fibers continue inserting for a distance down the medial edge of the common tendon. When the biceps femoris contracts during flexion of the knee, the long head becomes shorter, wider, rounder, conspicuous, and *separate* from the form of the short head. The form of the long head, especially its lower end, now lies medial to the now prominent short head, whose posterior edge (and overlying tendon) has been raised into a ridge. The overlying tendon now curves around the short head's posterior surface, and the lower end of the long head appears to insert into the *medial side of the form of the short head*. The axes of the forms of the long and short heads are no longer in line with each other in the flexed knee—the long head is oblique, while the short head is vertical (seen from the back view). In this position, the lower half of the short head pulls away from the femur, and a depression forms between this portion of the short head and the vastus lateralis (seen in side view).



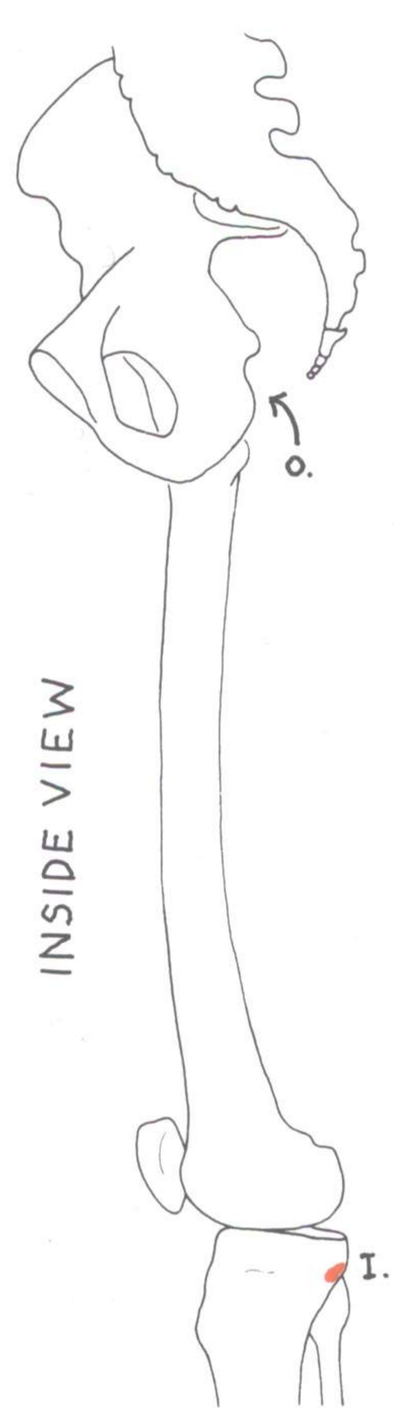


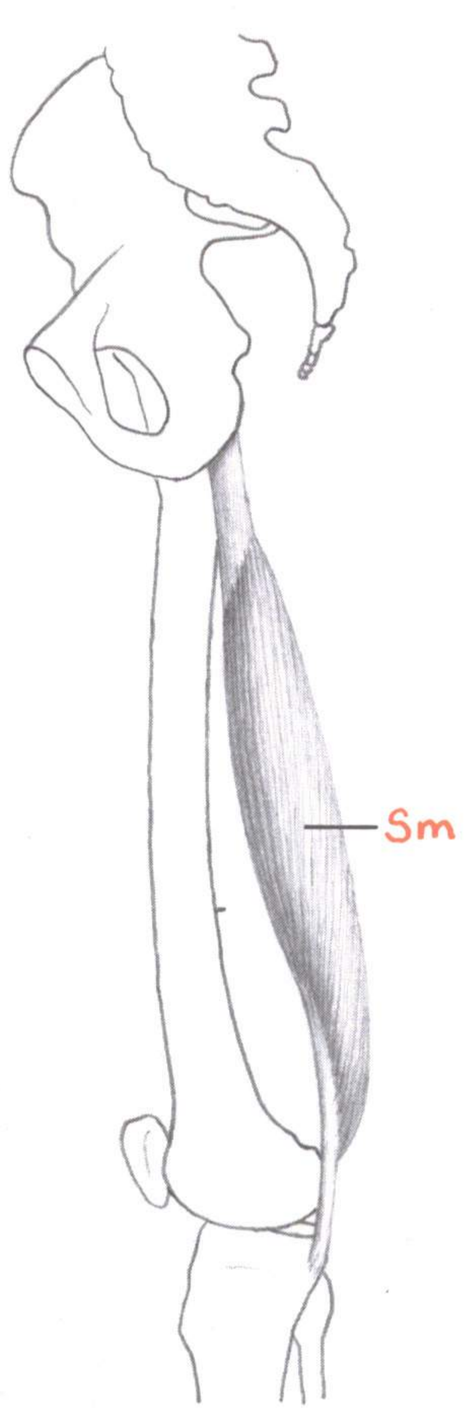


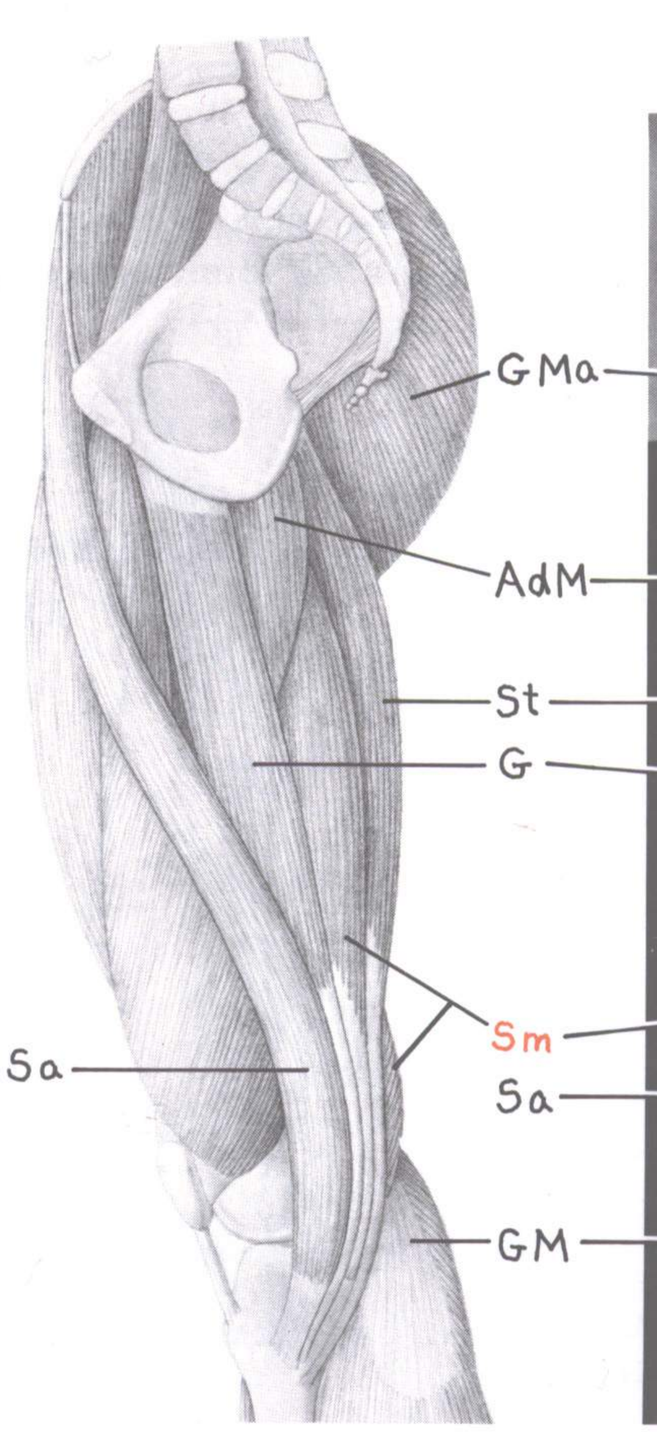


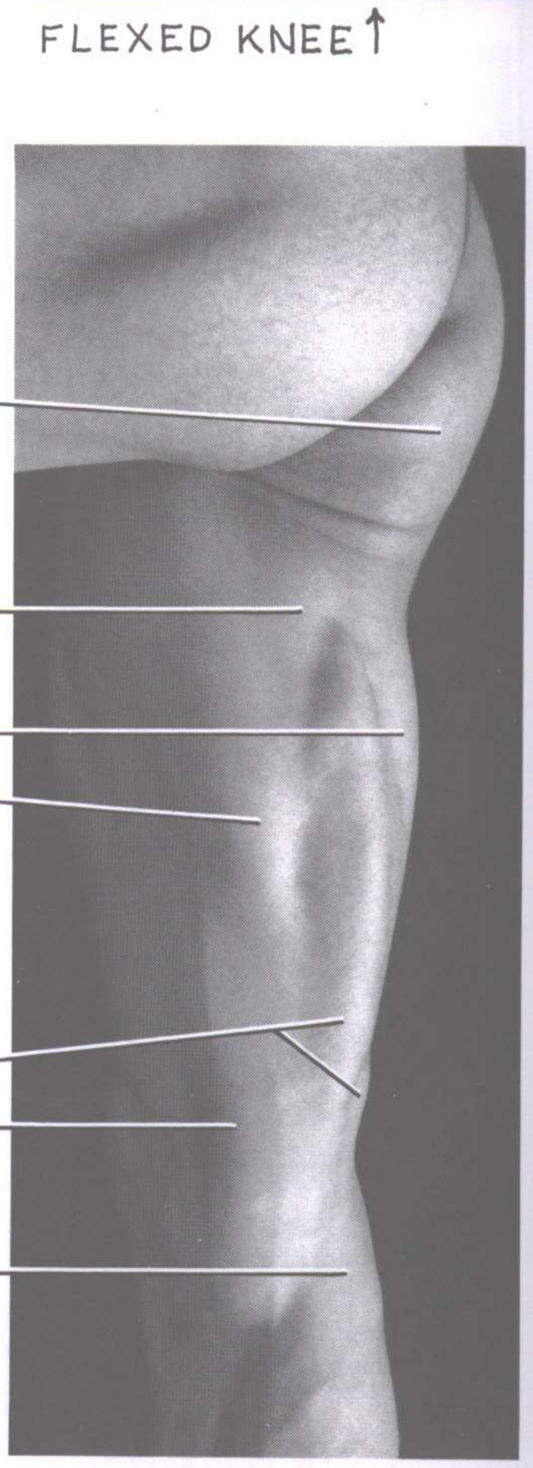


FLEXED KNEE ↑

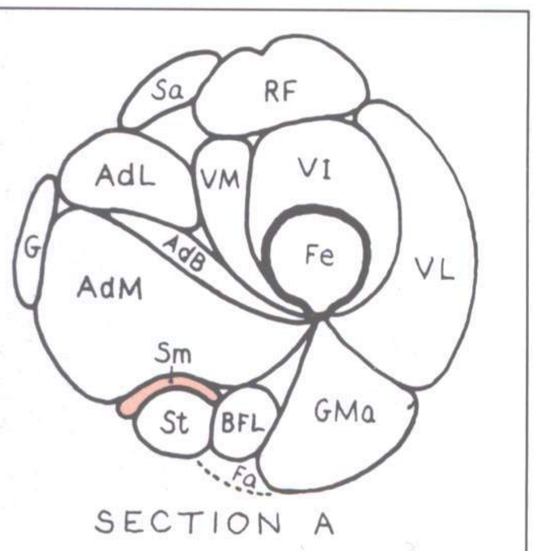








AdM *Adductor magnus* **BFL** *Biceps femoris—long head* **BFS** *Biceps femoris—short head* **Fa** *Fat* **Fe** *Femur* **G** *Gracilis* **GM** *Gastrocnemius—medial head* **GMa** *Gluteus maximus* **Sa** *Sartorius* **Sm** *Semimembranosus* **St** *Semitendinosus*



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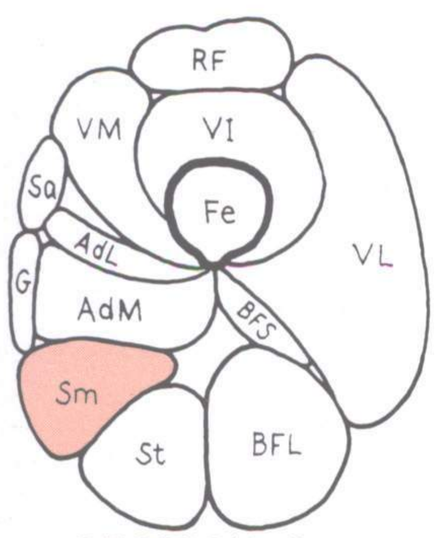

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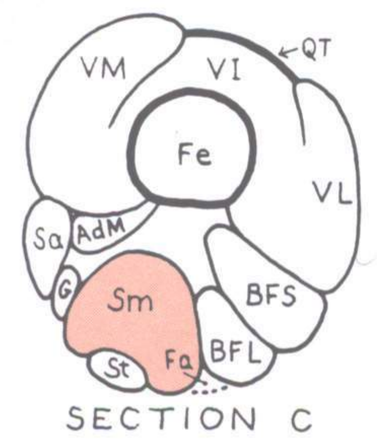

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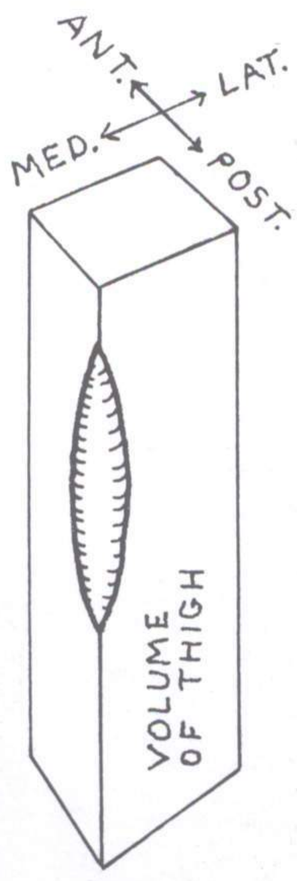


MEDIAL PORTION ON INNER BACK CORNER OF THIGH

Semimembranosus

ORIGIN Upper lateral facet of the ischial tuberosity of the pelvis (under and lateral to the origin of the long head of the biceps femoris).

INSERTION A horizontal groove on the posteromedial surface of the medial condyle of the tibia (not onto the shaft).

ACTION Flexes the lower leg at the knee joint and then medially rotates it; extends the thigh at the hip joint.

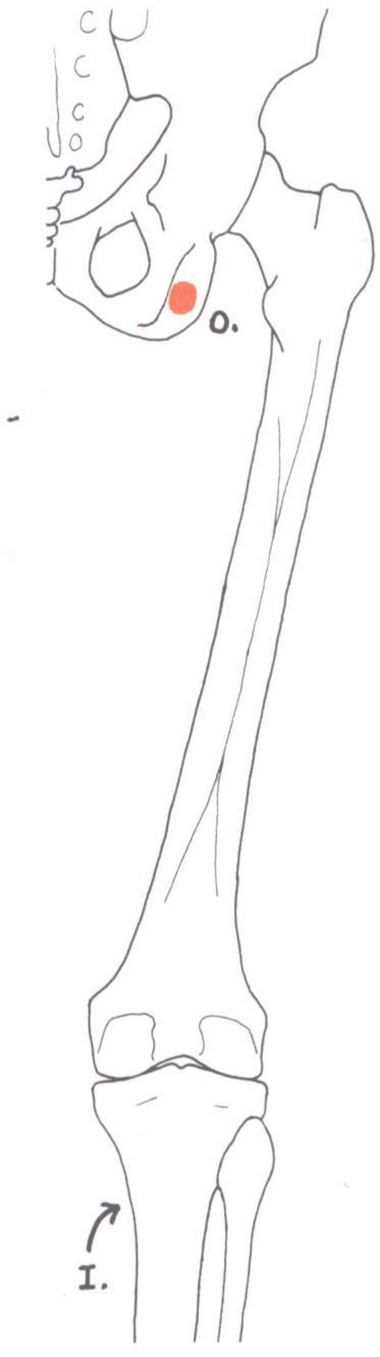
STRUCTURE The semimembranosus consists of a fleshy muscle belly with a tendon at each end. It begins superiorly as a wide "membranous" tendon that is curved side to side to form a longitudinal channel. The channel extends down into its fleshy muscle belly, and the belly of the semitendinosus lies in this gully. The semimembranosus ends in a strong, flattened tendon that arises from the medial side of its muscle belly. This tendon is located between the tendons of the semitendinosus and gracilis on the inner back corner of the knee, but is never visible on the surface. The muscle fibers of the fleshy belly extend downward to the level of the middle of the medial condyle of the femur, which brings these fleshy fibers in contact with the fleshy fibers of the medial head of the gastrocnemius.

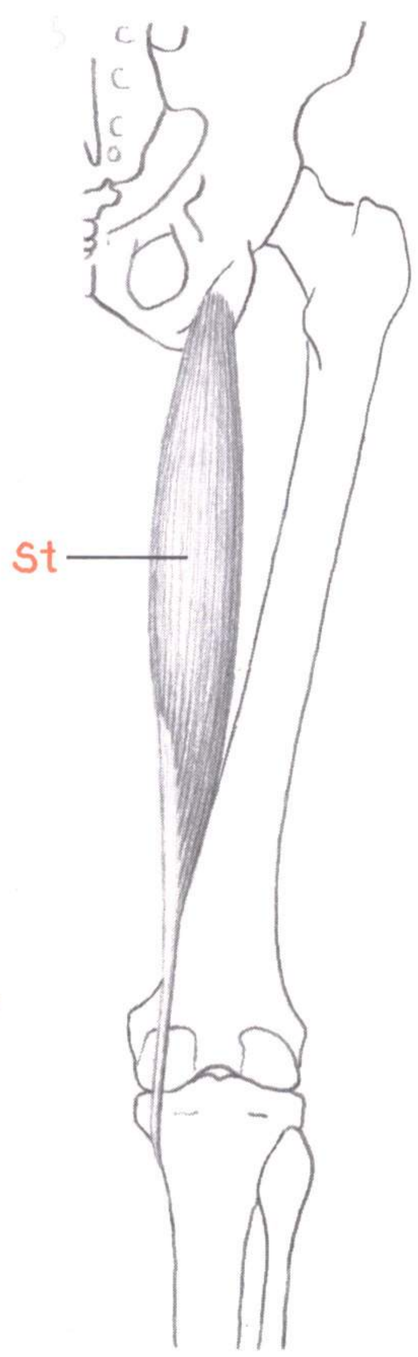
The muscle belly of the semimembranosus is partly superficial on either side of the semitendinosus—*medial* to it as an elongated form on almost the entire length of the inner back corner of the thigh and *lateral* to the lower portion of its belly and tendon. The lower lateral portion lies just above the back of the knee, where it fills most of the popliteal space and butts up against the biceps femoris. This portion can be thought of as a downward extension of the elongated form of the semitendinosus belly situated immediately superior to it; the combined form lies just medial to the midline of the back of the thigh. The lower lateral portion bulges during full knee extension, although it is partially or completely covered by the popliteal fat pad. When the fat is thin, this portion of the semimembranosus contributes directly to the popliteal bulge that develops lateral to the furrow caused by the semitendinosus tendon (only in the extended knee).

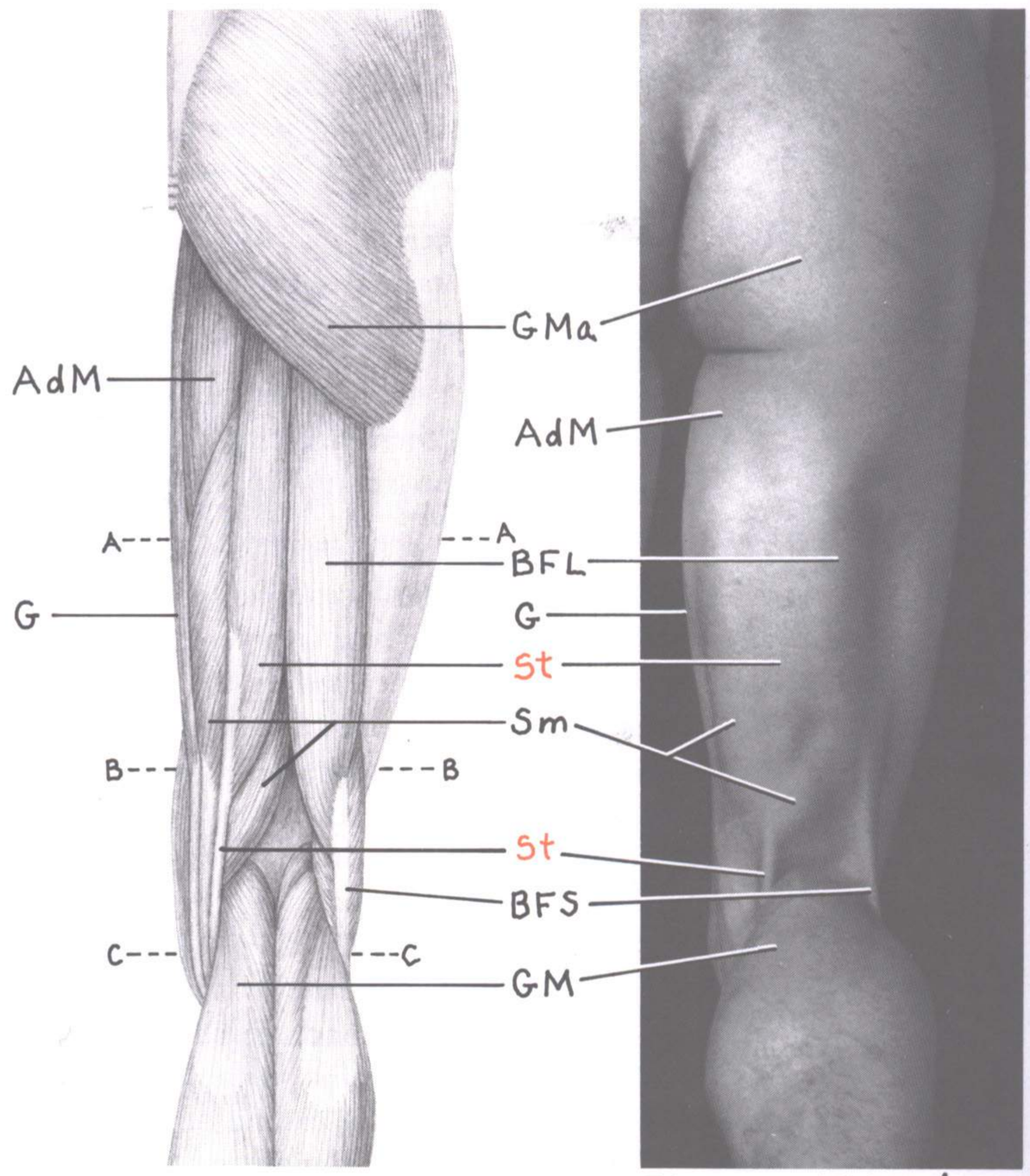
The medial portion of the semimembranosus does not extend all the way up to the gluteus maximus, but ends in a point where the semitendinosus and adductor magnus bellies meet. An oblique **tendinous intersection,** directed downward and medially and parallel to the medial edge of the adductor magnus, is located across the upper part of this medial form. It sometimes separates the portion of the semimembranosus above it into an independent form.

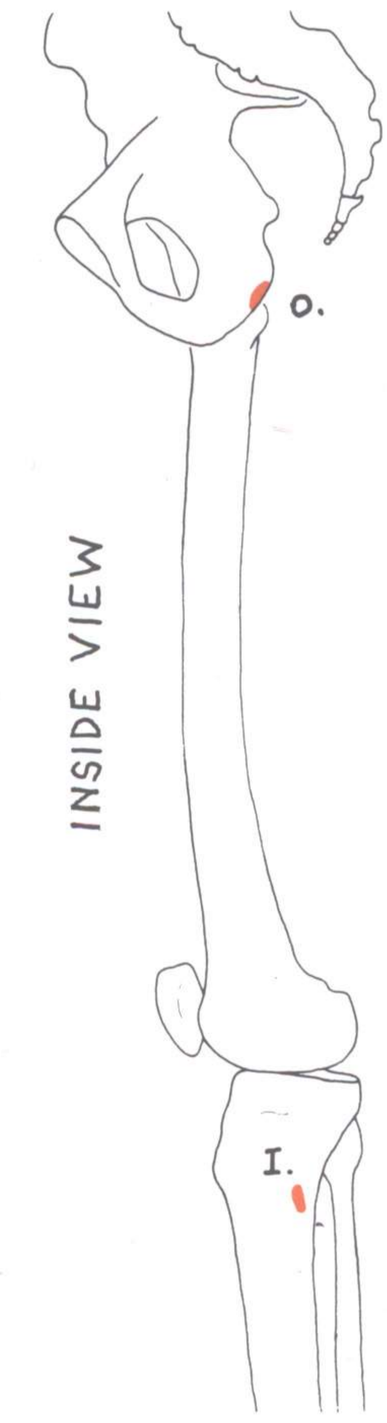
When the thigh is completely flexed at the hip joint and the knee is extended, the semimembranosus is stretched tight. It becomes thinner and the width of the medial portion of its belly forms a wide, depressed furrow between the bellies of the semitendinosus laterally and adductor magnus and gracilis medially.

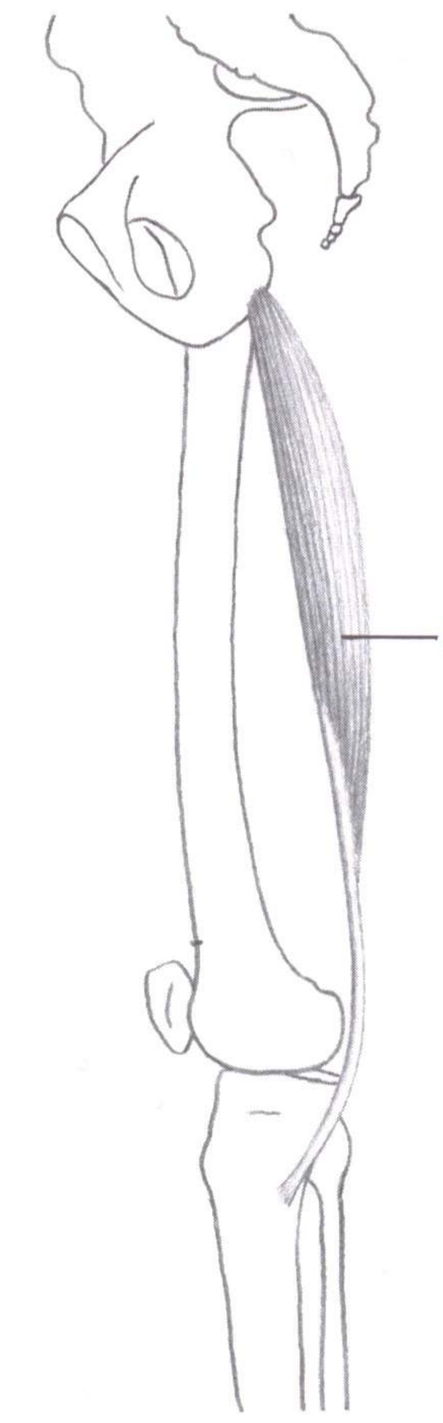
As the knee joint is fully flexed, more of the belly of the semimembranosus is revealed on the back of the thigh as the semitendinosus belly shortens and slides upward. Much of the belly of the semimembranosus now lies against the belly of the biceps femoris on the lower two-thirds of the back of the thigh. The upper portion of the semitendinosus tendon forms a furrow in the now-exposed upper portion of the belly of the semimembranosus. At the back of the flexed knee, the semitendinosus tendon moves posteriorly away from the knee, pulling the skin with it. The lower end of the belly of the semimembranosus is then no longer seen on the surface.

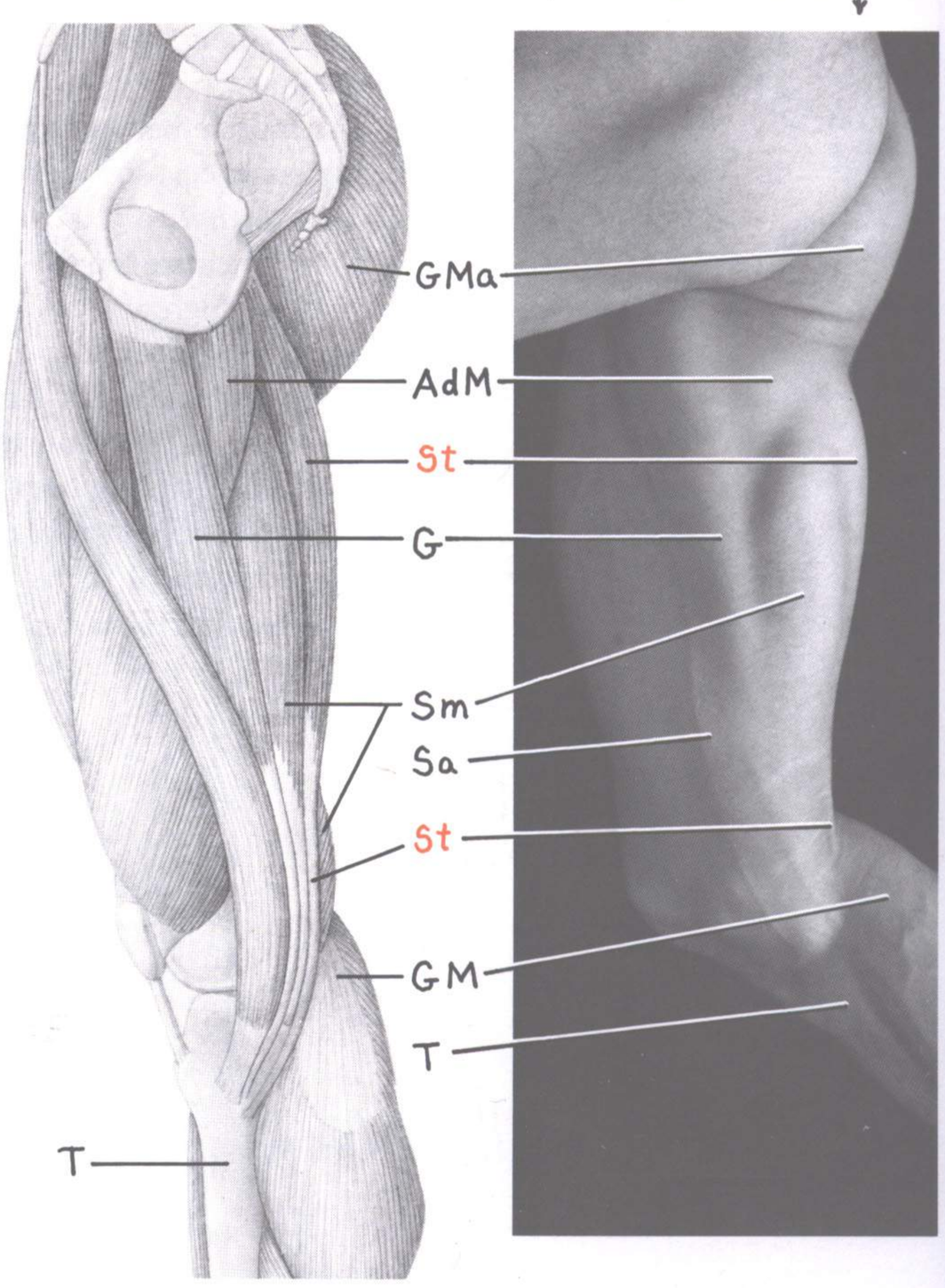




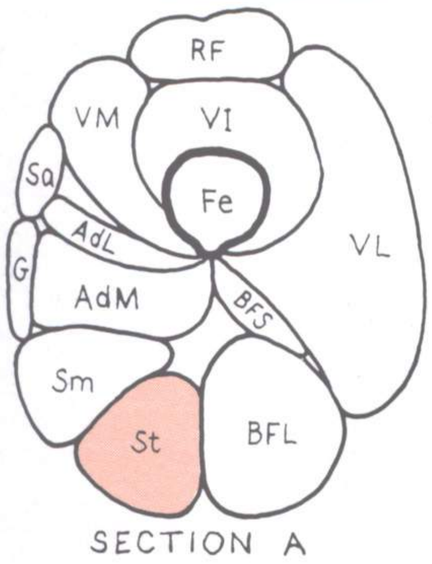




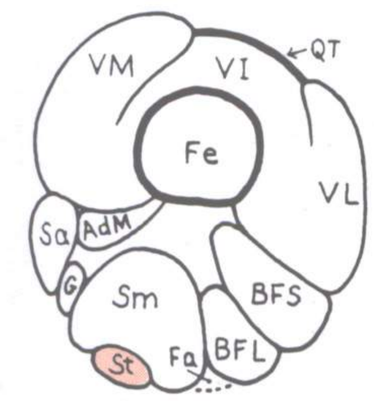




AdM *Adductor magnus* **BFL** *Biceps femoris—long head* **BFS** *Biceps femoris—short head* **Fa** *Fat* **Fe** *Femur* **G** *Gracilis* **GM** *Gastrocnemius—medial head* **GMa** *Gluteus maximus* **Sa** *Sartorius* **Sm** *Semimembranosus* **St** *Semitendinosus* **T** *Tibia*



SECTION A



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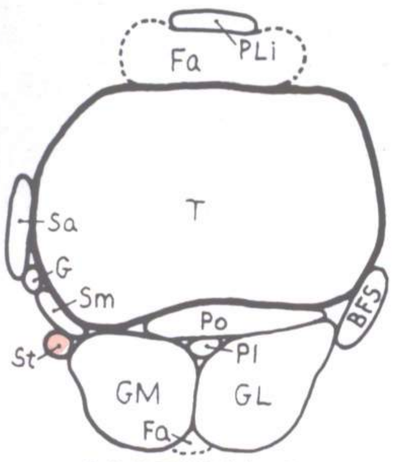


SECTION C

Semitendinosus

ORIGIN Ischial tuberosity of the pelvis (in common with the long head of the biceps femoris).

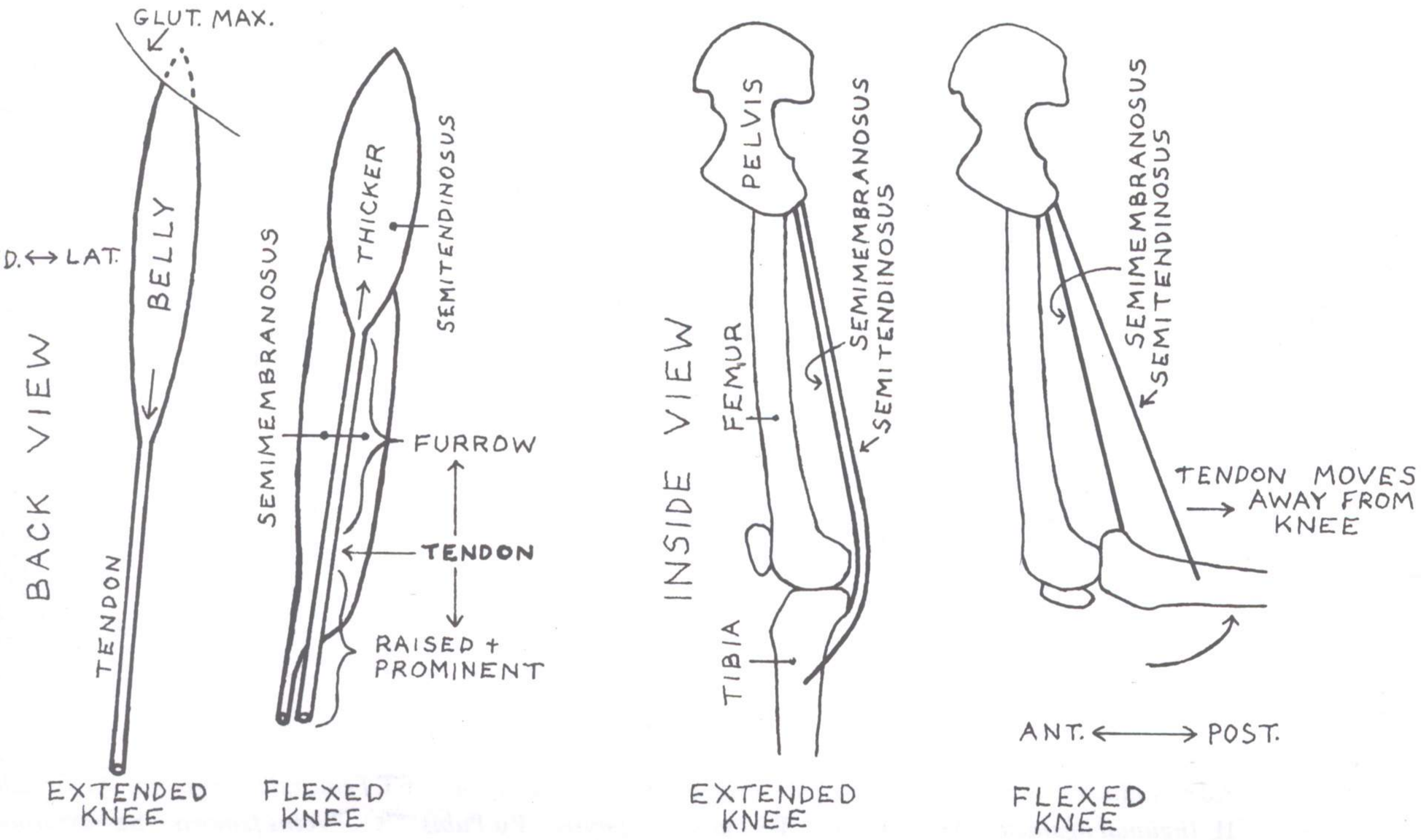
INSERTION Upper part of the medial surface of the shaft of the tibia, below the medial condyle, in common with the sartorius and gracilis.

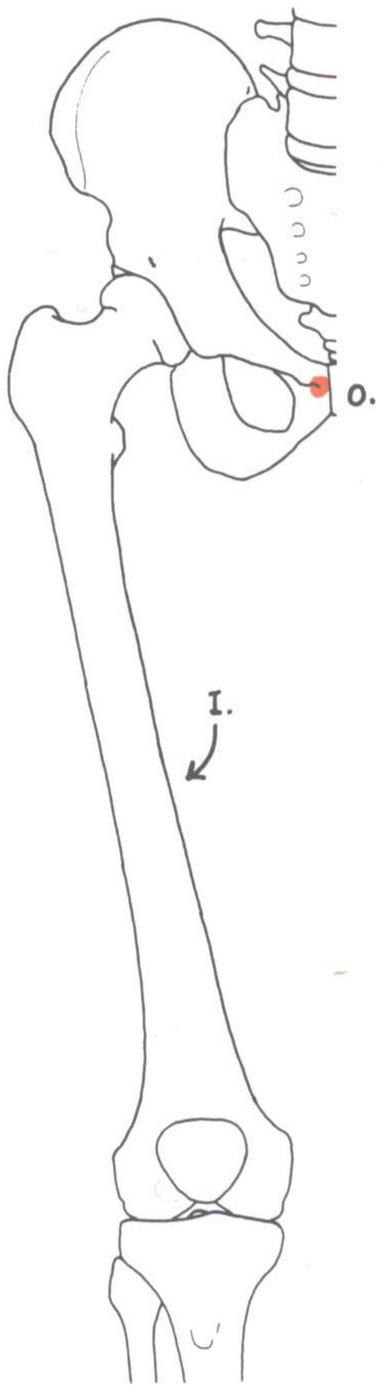
ACTION Flexes the lower leg and then medially rotates it; extends the thigh at the hip joint.

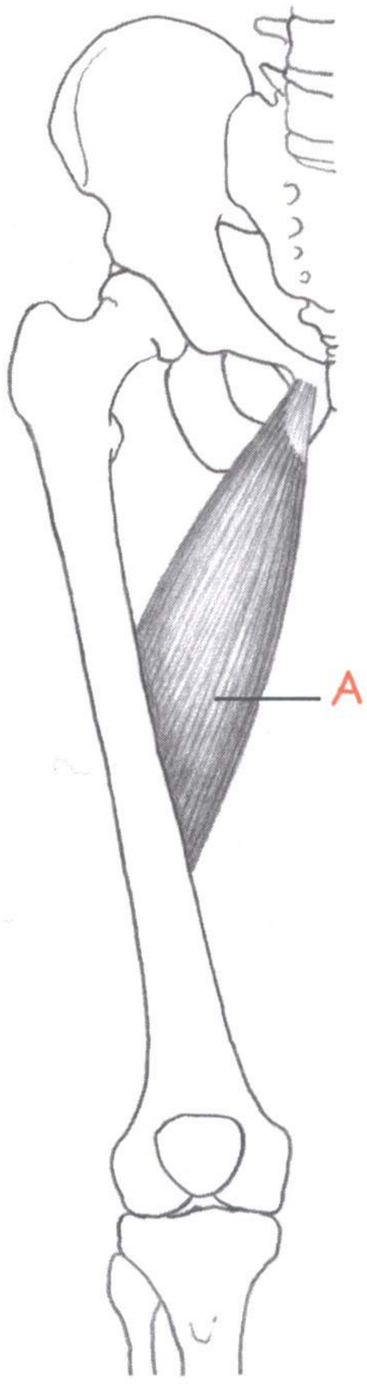
STRUCTURE The long, narrow, fleshy belly of the semitendinosus ends two-thirds of the way down the thigh at its tendon and sits in the shallow, longitudinal muscular groove formed in the semimembranosus muscle. It is located just medial to the midline of the back of the thigh. Its long, cordlike tendon of insertion begins on the *medial* side of its belly, passes down on the middle of the lower half of the belly of the semimembranosus, continues behind the medial condyles of the femur and tibia, and finally curves forward (lying against the medial head of the gastrocnemius) to reach its insertion. This tendon becomes very prominent during knee flexion as it moves away from the back of the upper leg (it also moves away from the semimembranosus). When the knee joint is extended, the tendon is pulled tight, producing a narrow vertical furrow on the back of the knee, medial to the popliteal bulge (made up of the bulging popliteal fat and the underlying part of the semimembranosus). The furrow is more pronounced in the female.

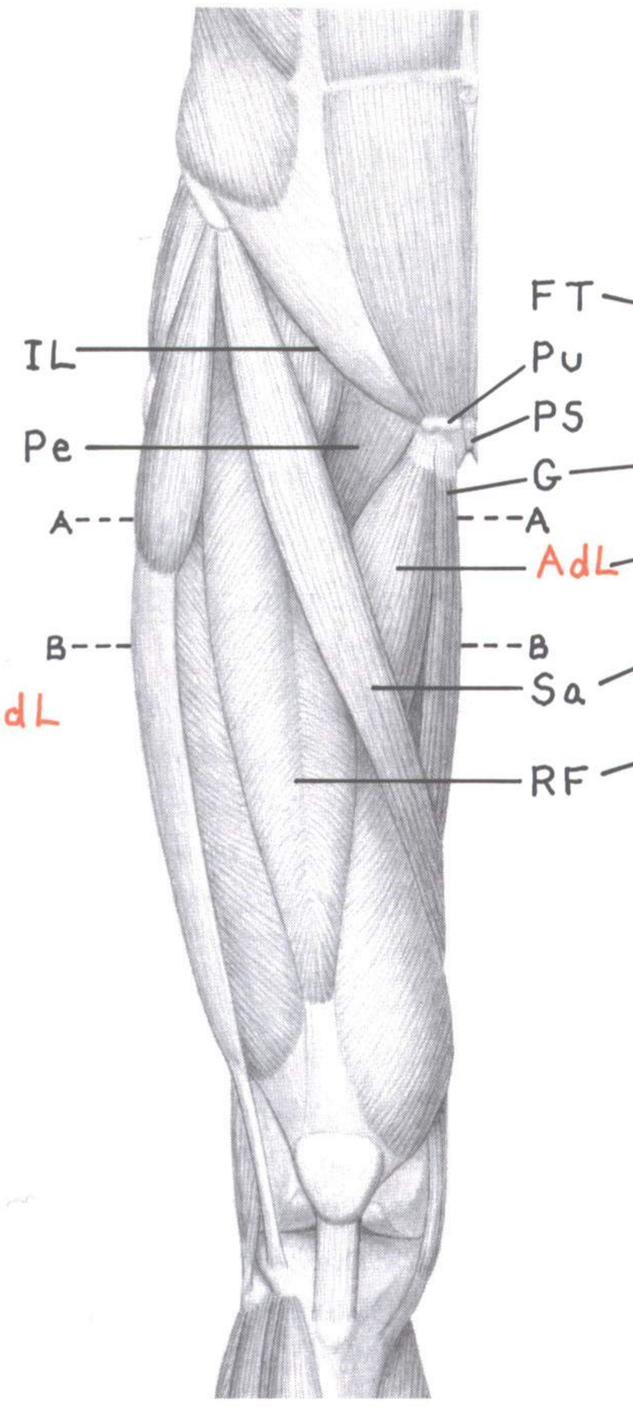
When the knee is extended and the pelvis is flexed forward at the hip joint, stretching the hamstring muscles, the muscle belly of the semitendinosus and the lower lateral portion of the semimembranosus immediately below it together produce an elongated raised form down the back of the thigh just medial to the midline. When the knee is flexed, the inferior end of the belly of the semitendinosus rises considerably (exposing more of the belly of the semimembranosus). The upper portion of its long tendon of insertion then becomes a furrow, and the lower portion of the tendon becomes a very prominent raised ridge. In this position, the semitendinosus tendon on the medial side of the back of the knee projects further posteriorly than does the biceps femoris tendon on the lateral side of the back of the knee.

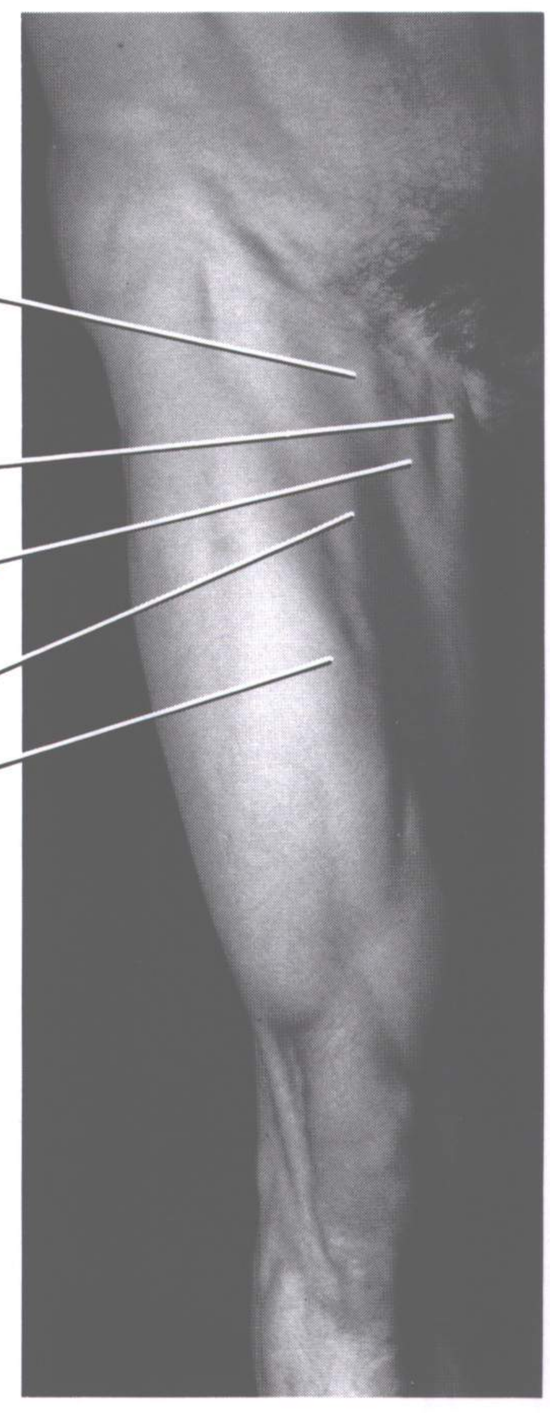
The superior end of the belly of the semitendinosus maintains its width as it passes under the lower edge of the gluteus maximus. At this point, it is in contact with the adductor magnus medially, not the semimembranosus.

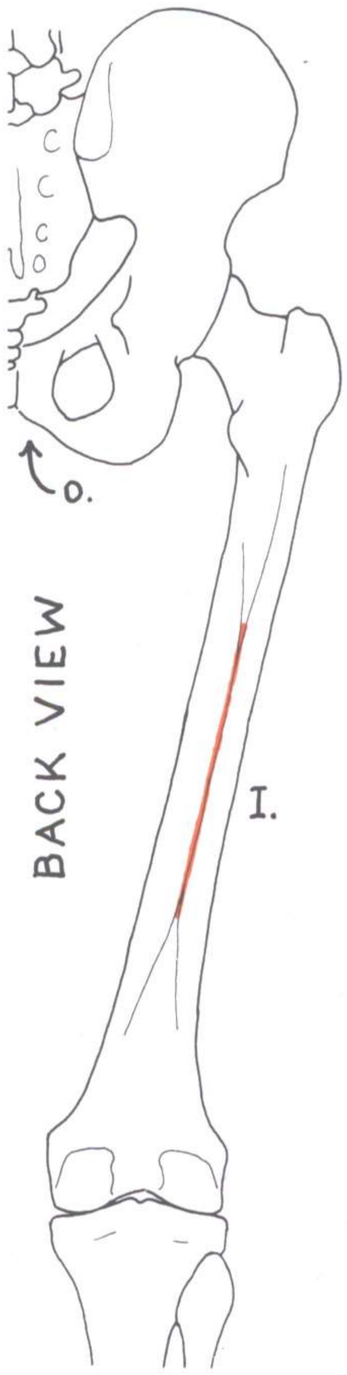




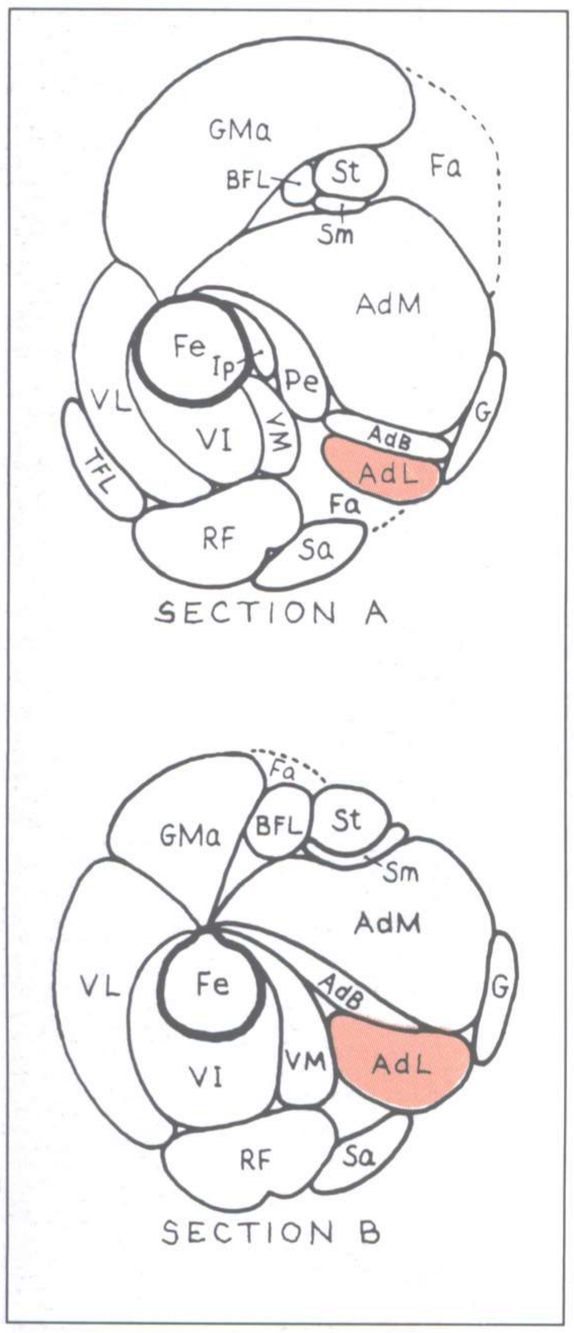








AdB *Adductor brevis* **AdL** *Adductor longus* **Fa** *Fat* **Fe** *Femur* **FT** *Femoral triangle fat* **G** *Gracilis* **IL** *Inguinal ligament* **Pe** *Pectineus* **PS** *Pubic symphysis* **Pu** *Pubis* **RF** *Rectus femoris* **Sa** *Sartorius* **VM** *Vastus medialis*



Adductor Longus

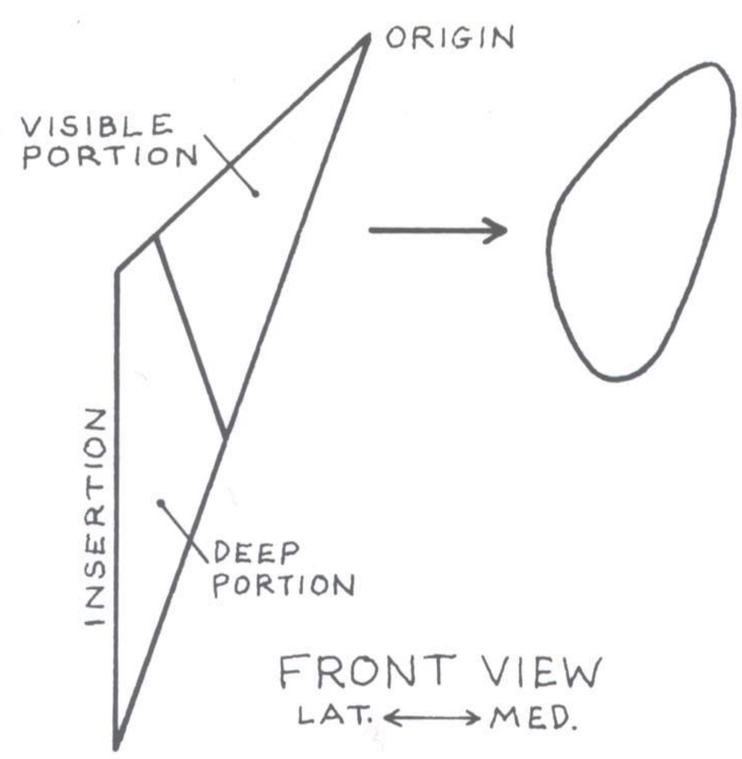
ORIGIN Small round area on the outer surface of the anterior portion of the pubic bone of the pelvis, just below the pubic tubercle and just lateral to the pubic symphysis.

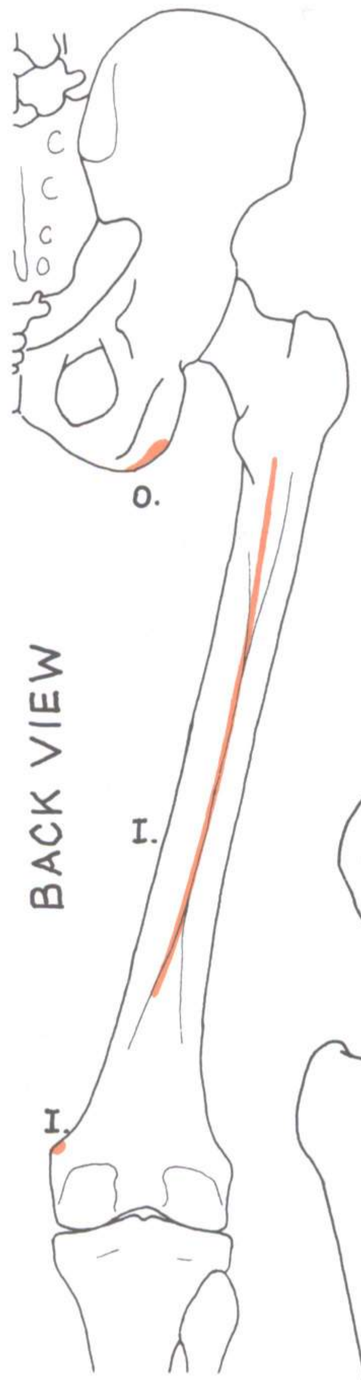
INSERTION A vertical line on the middle third of the back of the femur (on the medial lip of the linea aspera).

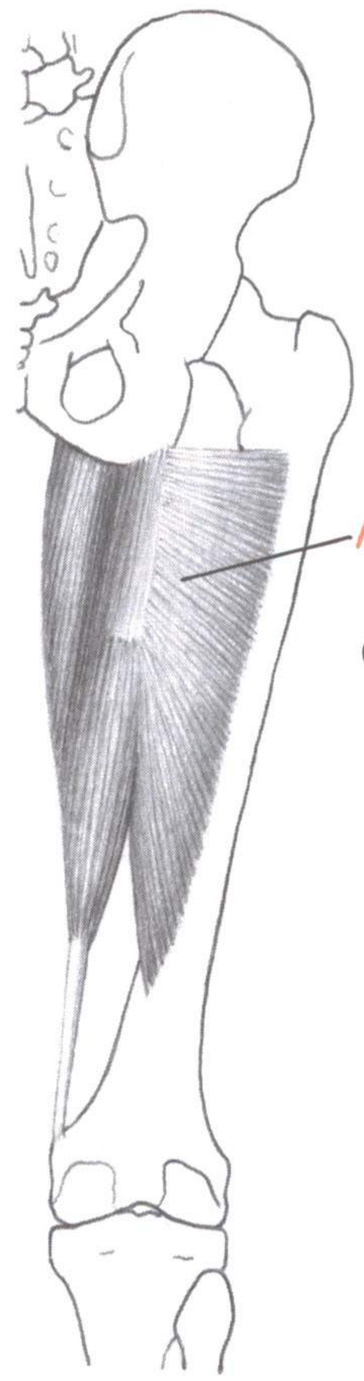
ACTION Adducts, flexes, and medially rotates the thigh.

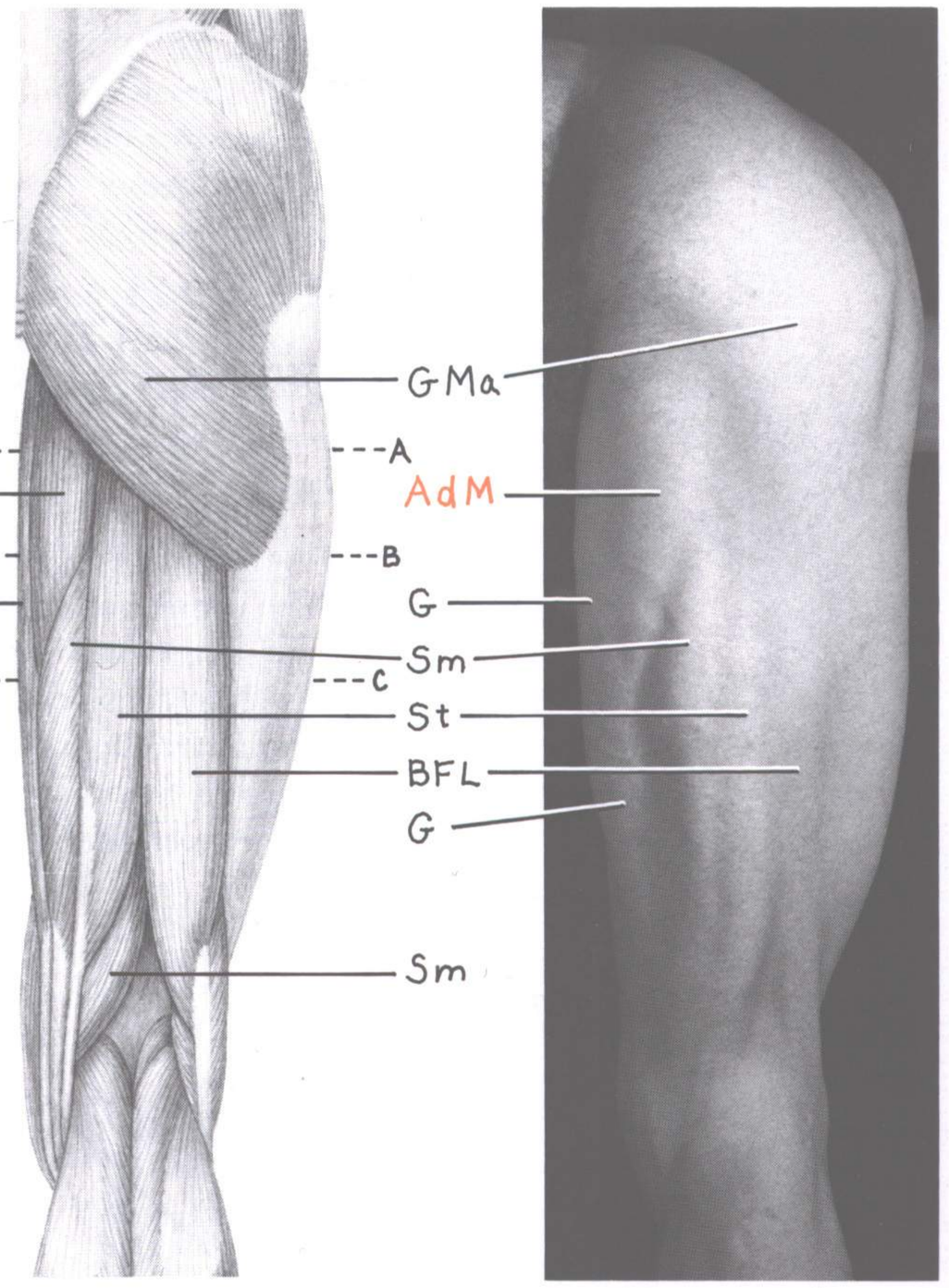
STRUCTURE The adductor longus is a long, triangular muscle, originating with both fleshy fibers and a strong tendon. The tendinous portion is often conspicuous in the groin when the legs are apart. Distally, the fleshy belly thins into a wide, flat tendon where it inserts into the femur between the vastus medialis and adductor magnus. The adductor longus passes from the *front* of the pelvis to the *back* of the femur. It lies on the front of the mass of the adductor group, medial to the fat and neurovascular bundle of the femoral triangle. Inferiorly, it disappears under the sartorius. It is usually not defined on the surface since the adductor muscles usually appear as a single mass rather than as individual muscles. However, when it does show up, it is seen as an oval or triangular swelling on the medial portion of the front of the upper half of the thigh. This form narrows as it nears its origin on the pelvis.

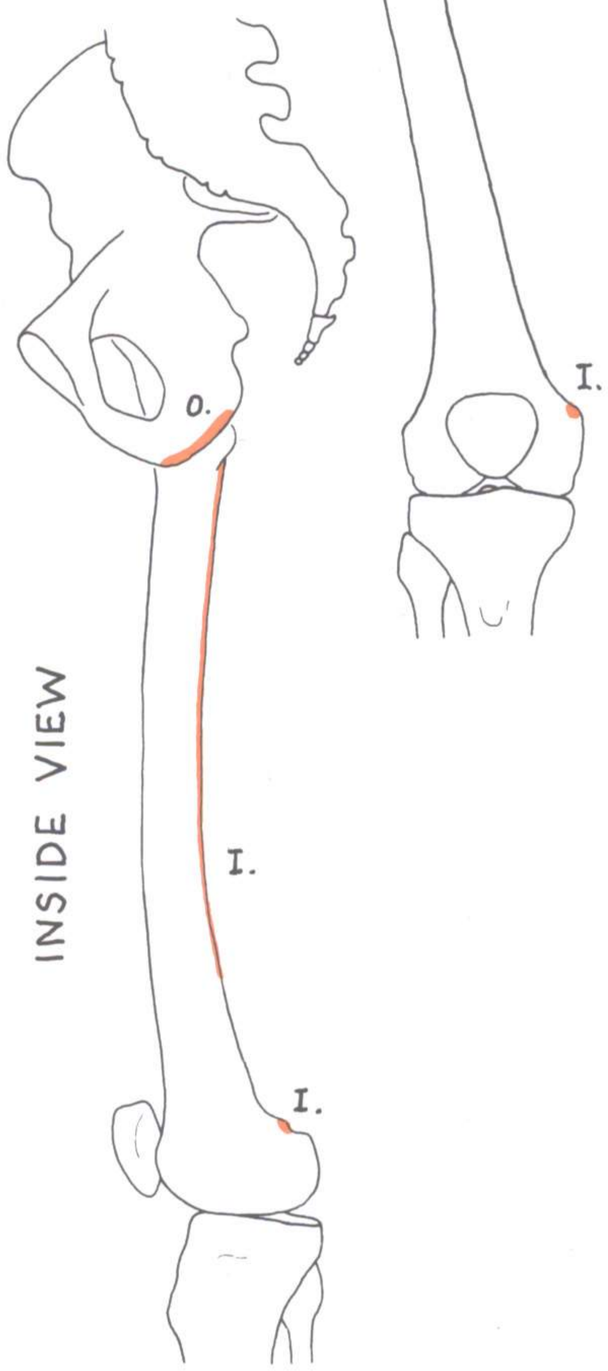
When both tendons of origin of the adductor longus and gracilis are seen in the groin, the rounder (more cylindrical) adductor longus tendon is located anterior and lateral to the flat gracilis tendon.

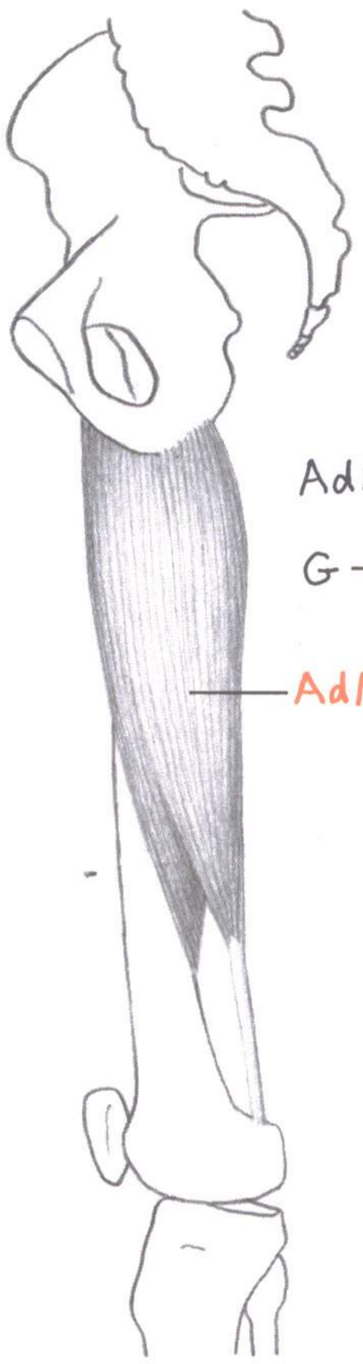


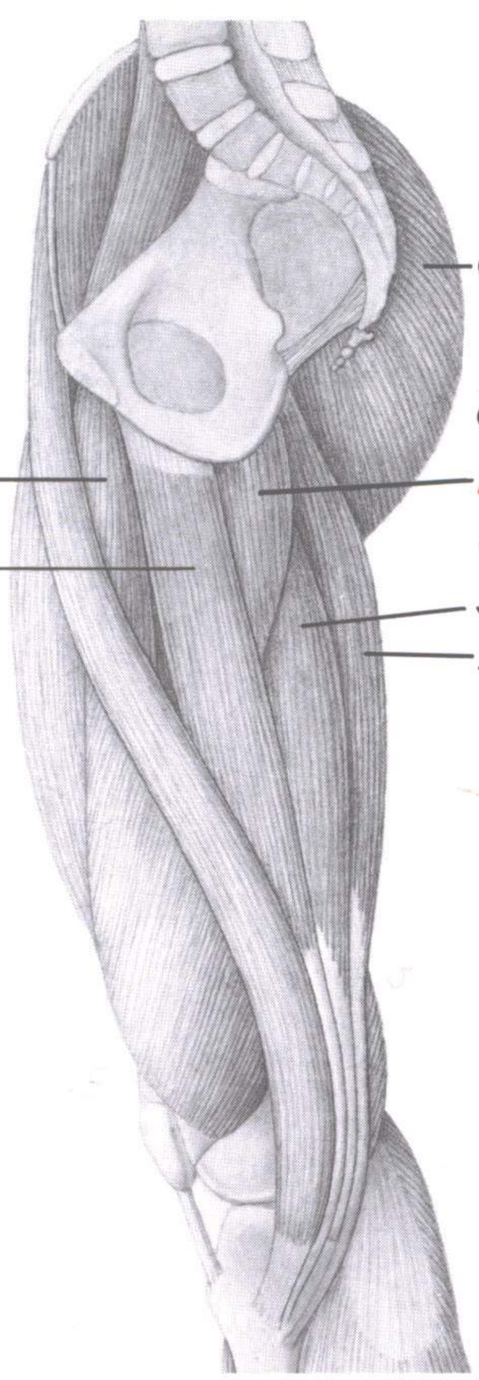


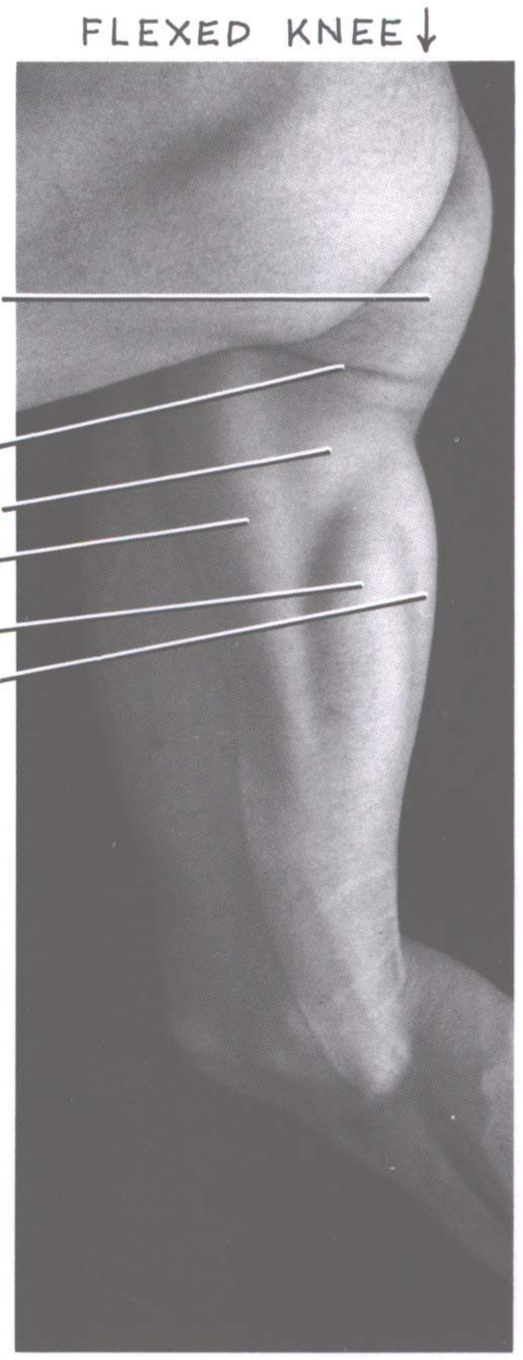




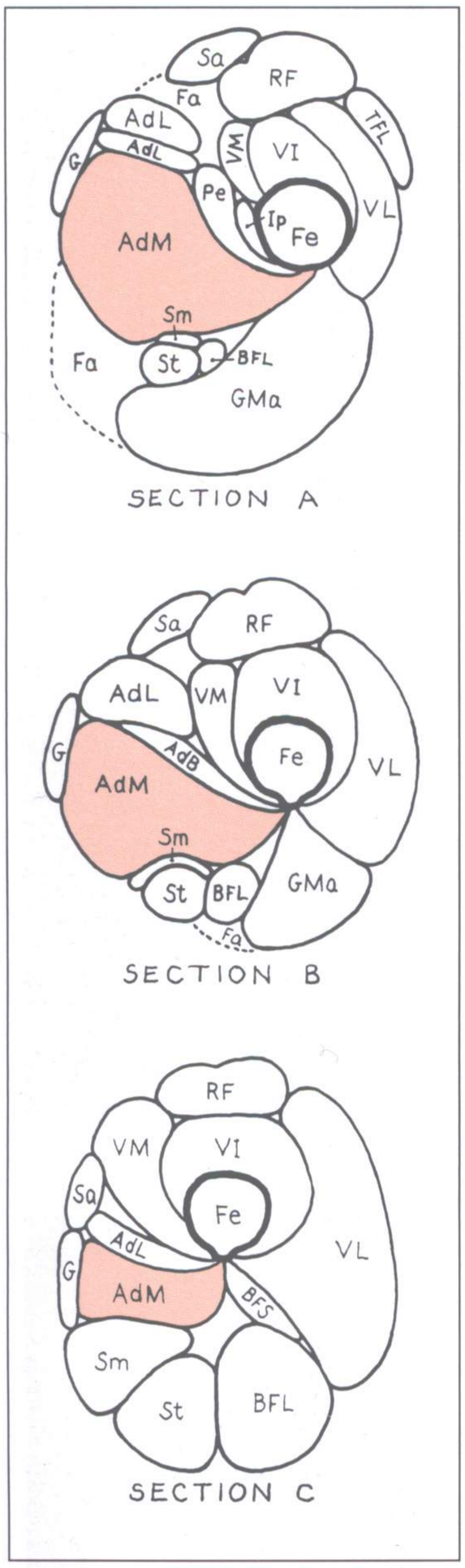








AdB *Adductor brevis* **AdL** *Adductor longus* **AdM** *Adductor magnus* **BFL** *Biceps femoris—long head*
BFS *Biceps femoris—short head* **Fa** *Fat* **Fe** *Femur* **G** *Gracilis* **GFo** *Gluteal fold*
GMa *Gluteus maximus* **Pe** *Pectineus* **Sm** *Semimembranosus* **St** *Semitendinosus*



Adductor Magnus

ORIGIN A line beginning on the lower lateral portion of the ischial tuberosity, extending along the inferior edge of the lateral surface of the ramus of the ischium, and then continuing forward along the posterior part of the ramus of the pubis (just above its inferior edge).

INSERTION A line down the middle of the back of the femur, beginning at the level of the lesser trochanter, leading to and passing down the linea aspera, and the adductor tubercle of the femur, just above the medial condyle.

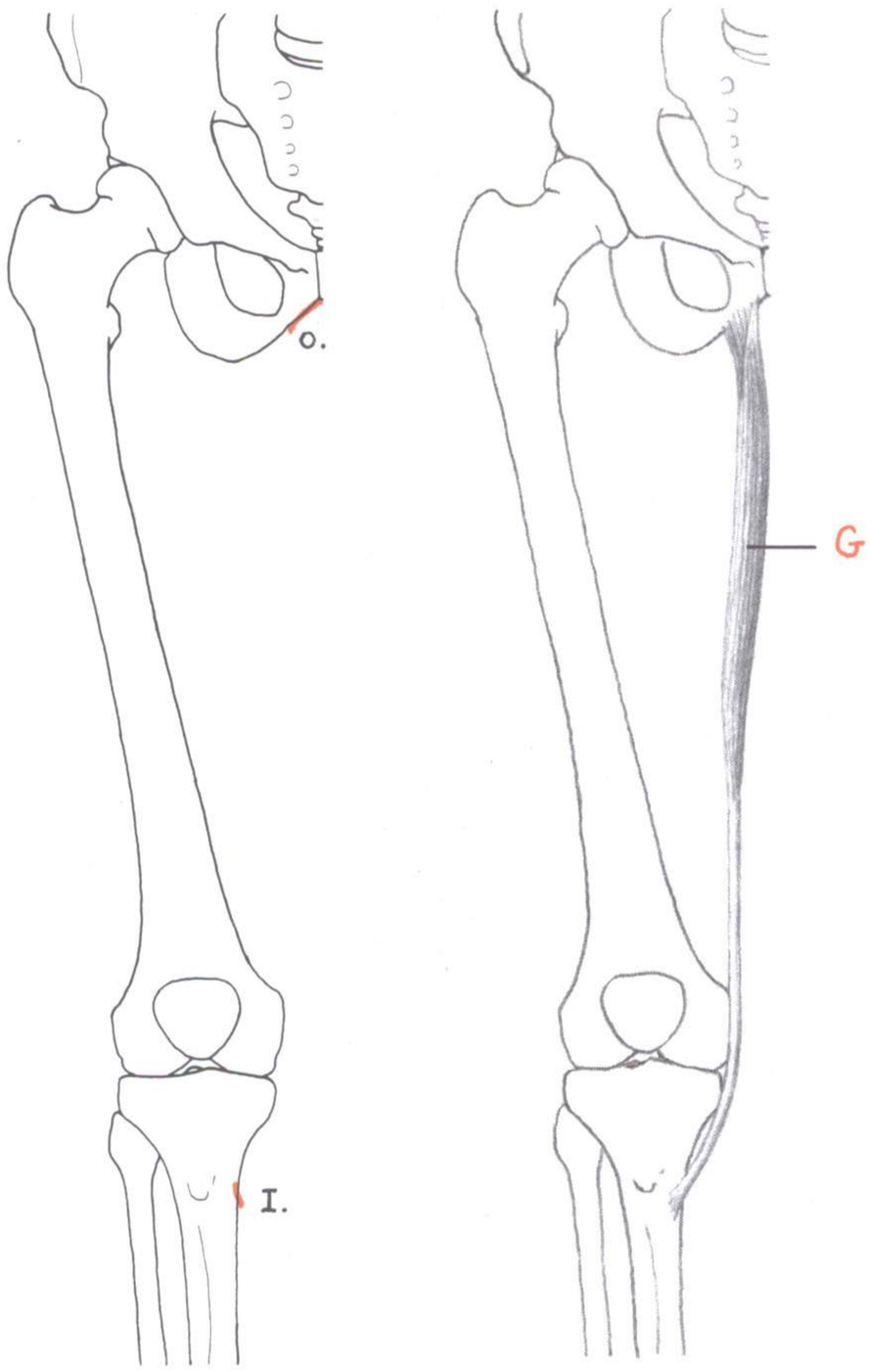
ACTION Powerfully adducts the thigh. Gravity, however, usually adducts the thigh in the standing position, with the adductor magnus remaining relaxed. The oblique anterior fibers (upper or obturator portion) assist in flexion of the thigh, while the long, vertical, posterior portion (lower portion or ischial head) assists in extension of the thigh, especially if the hip joint has already been flexed (it functions like a hamstring hip joint extensor).

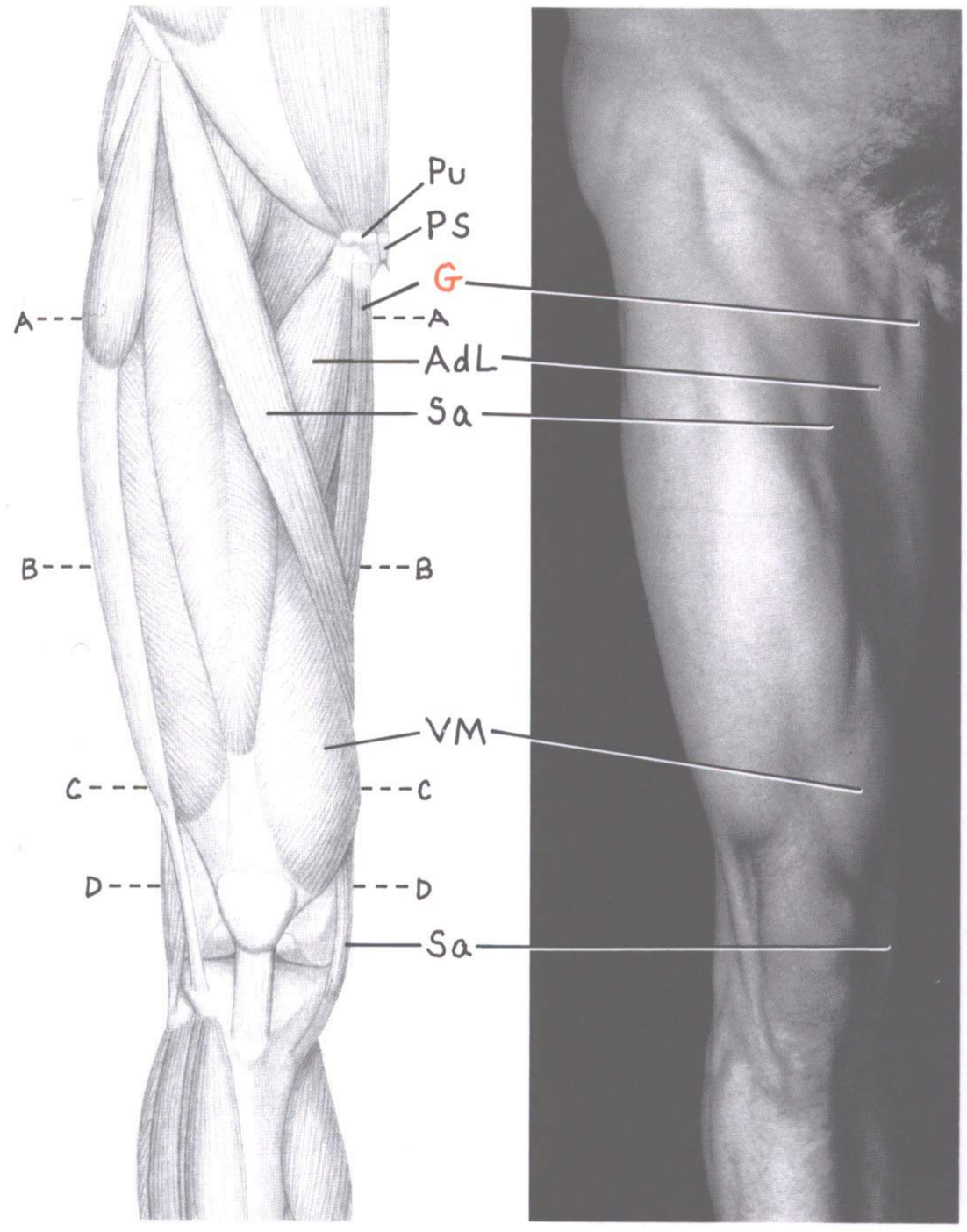
STRUCTURE The adductor magnus is a large powerful muscle located on the inside of the thigh. Its inferiorly pointed, somewhat conical form contributes substantially to the mass of the adductor group, which in turn blends with the hamstring group to create the large oblique form on the back of the thigh (directed upward, medially, and forward). The long internal edge of the adductor magnus passes between the masses of the hamstring and quadriceps groups to attach to its long line of insertion on the back of the femur. Two-thirds of the way down the thigh, the inverted conical form of the adductor magnus differentiates into a rounded tendon (not visible), which inserts into the adductor tubercle on the top of the medial condyle of the femur.

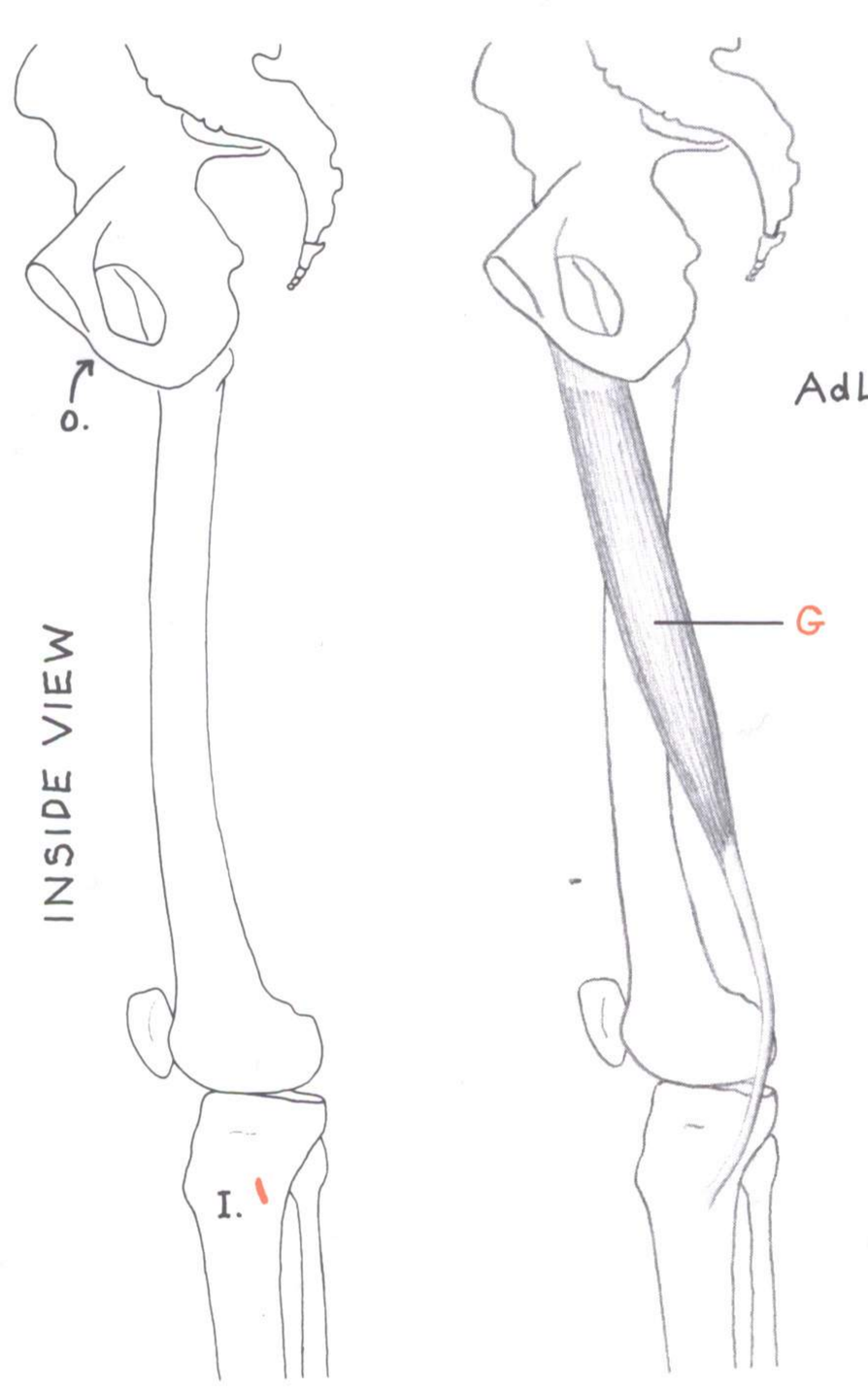
Only a small triangular area of the muscle is actually superficial. In low-fat individuals, its superficial part can be distinctly seen on the inner back corner of the upper end of the thigh when the pelvis is completely flexed forward at the hip joint and the knee remains extended. In this position the separation between the adductor magnus and the adjacent semitendinosus and semimembranosus is clearly seen. It is only occasionally distinguishable from the overlying gracilis. In this same position of full hip flexion, the adductor magnus is clearly seen emerging from under cover of the gluteus maximus. It disappears from view almost halfway down the thigh between the gracilis and semimembranosus.

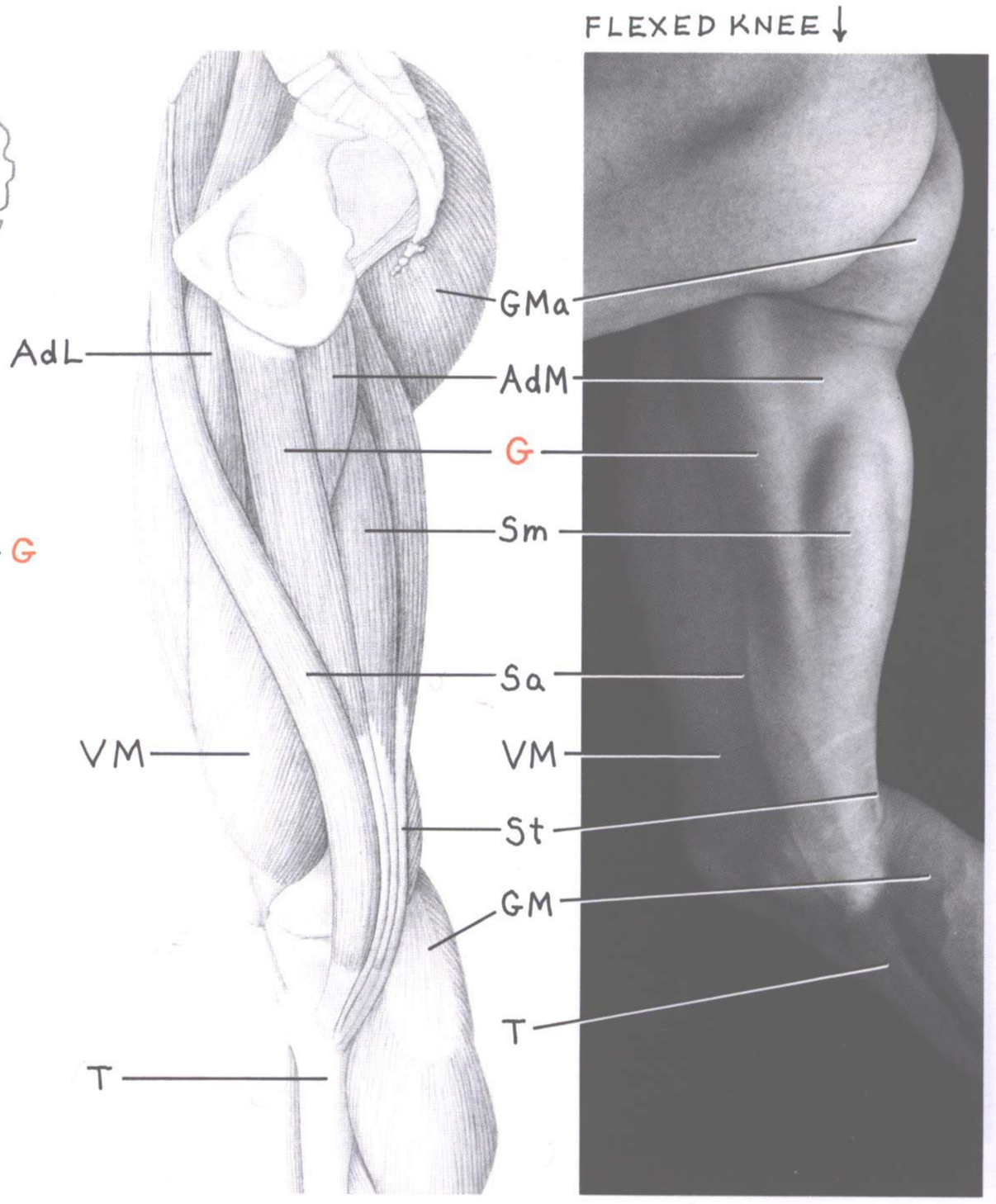
When the thigh is first completely flexed at the hip joint and the knee is then extended as far as possible, the semimembranosus is stretched tight and creates a wide, depressed furrow; the soft form of the adductor magnus bulges medial to this furrow.

The small uppermost portion of the adductor magnus is called the **adductor minimus.** It is not visible on the surface.

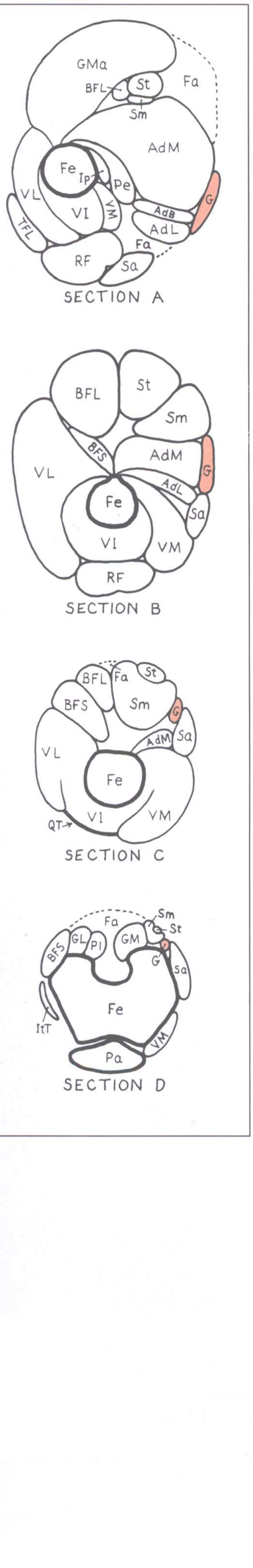








AdB *Adductor brevis* **AdL** *Adductor longus* **AdM** *Adductor magnus* **Fe** *Femur* **G** *Gracilis*
GM *Gastrocnemius—medial head* **GMa** *Gluteus maximus* **PS** *Pubic symphysis* **Pu** *Pubis*
Sa *Sartorius* **Sm** *Semimembranosus* **St** *Semitendinosus* **T** *Tibia* **VM** *Vastus medialis*



Gracilis

ORIGIN Inferior edge of the midsection of the pubic arch between the pubic symphysis and ischial tuberosity.

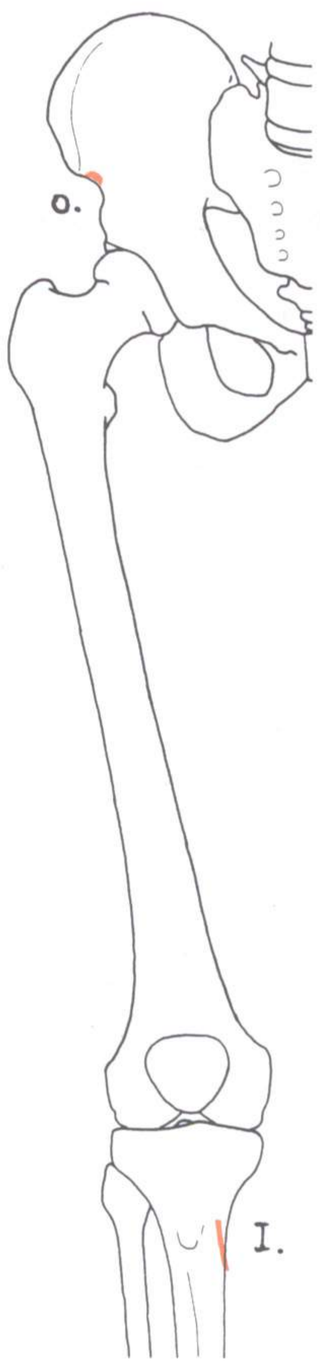
INSERTION Superior part of the medial surface of the shaft of the tibia, below the medial condyle, in common with the insertions of the sartorius and semitendinosus.

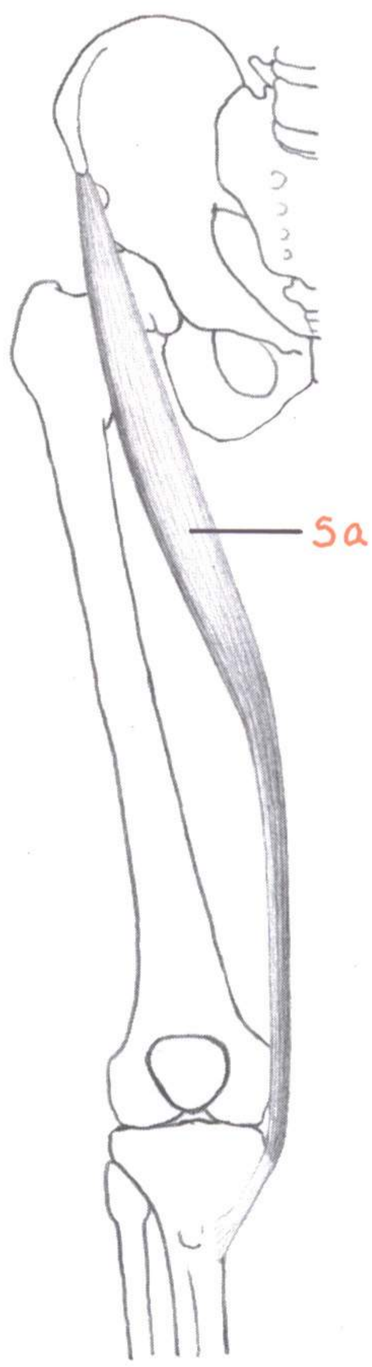
ACTION Adducts the thigh at the hip joint; flexes the lower leg at the knee joint and then assists in medial rotation of the lower leg.

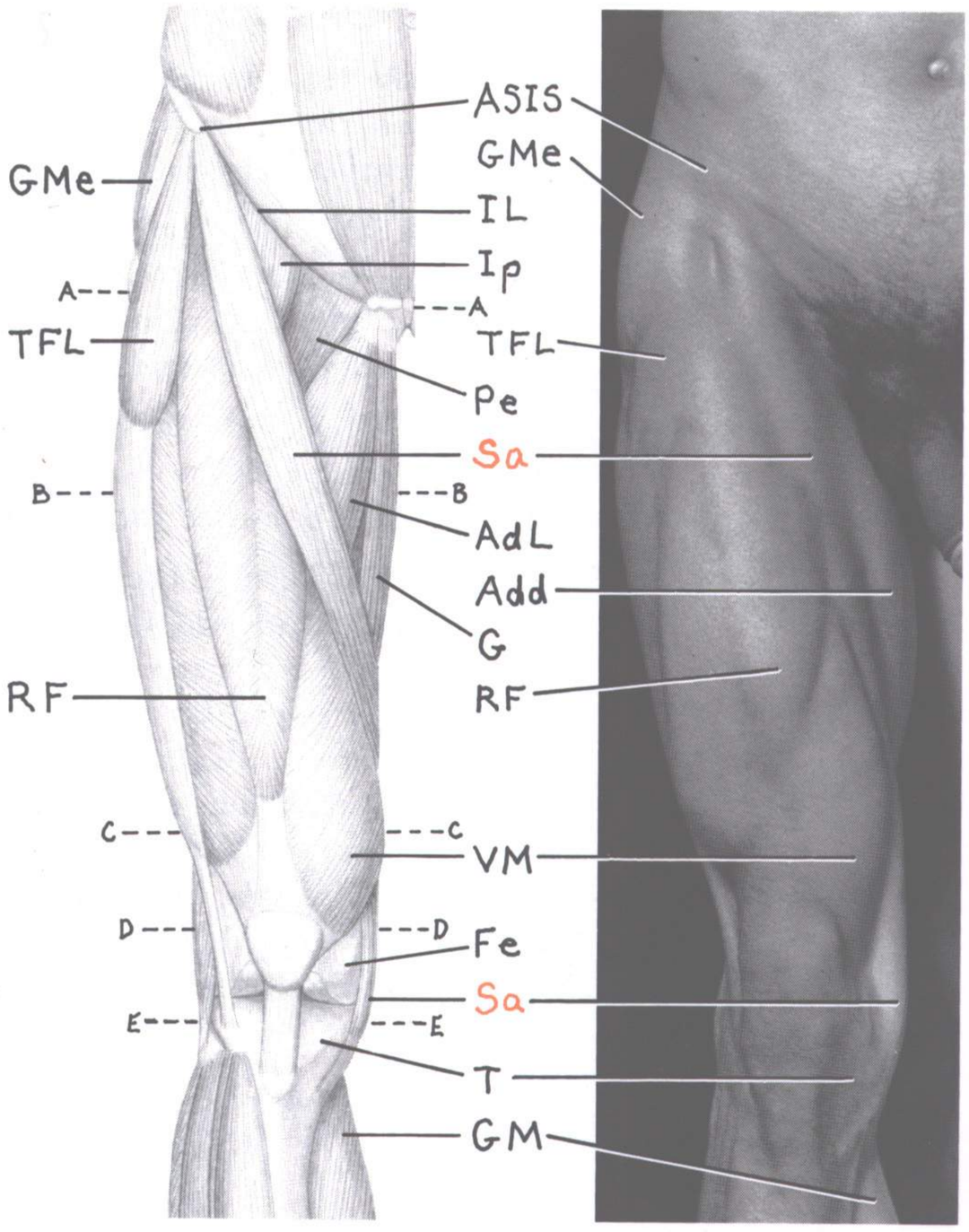
STRUCTURE The gracilis is a thin, wide, bandlike muscle. Its flattened belly is wider above and tapers inferiorly. Sitting on the inside of the thigh, this muscle is the most superficial and medial of the adductors. Beginning from its thin, tendinous upper end (approximately two inches wide), its belly passes down the inner surface of the thigh and develops into a rounded tendon two-thirds of the way down the thigh. The lower tendon is never seen in the straight leg. Only rarely is it seen on the inside back corner of the knee when the lower leg is flexed at the knee and medially rotated. When visible in this position, the gracilis tendon is directed along the inside of the thigh toward the midline of the base of the pelvis, whereas the more prominent semitendinosus tendon is directed obliquely toward the ischial tuberosity of the pelvis and is situated more laterally. Both tendons are easily palpated in the flexed knee when the muscles are tensed.

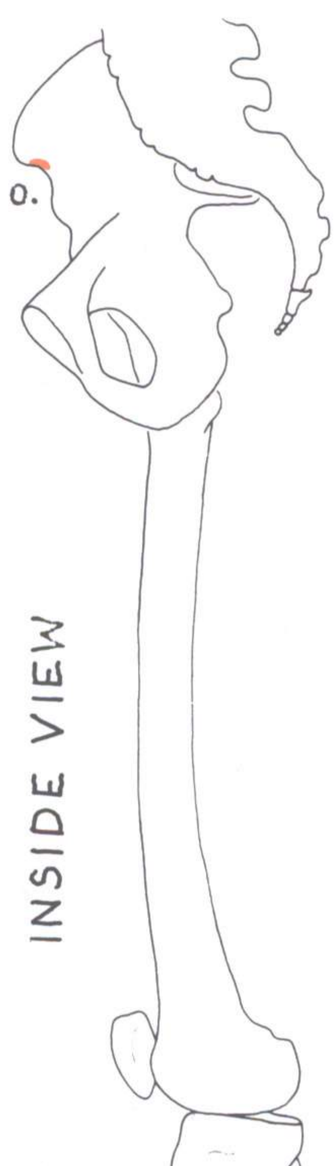
Although the thin muscular form of the gracilis for the most part blends with the mass of the other adductor muscles, it can often be seen prominently at its tendinous origin at the pelvis when the legs are apart, just posterior and medial to the rounded tendon of origin of the adductor longus. The belly of the gracilis may occasionally become defined on the surface.

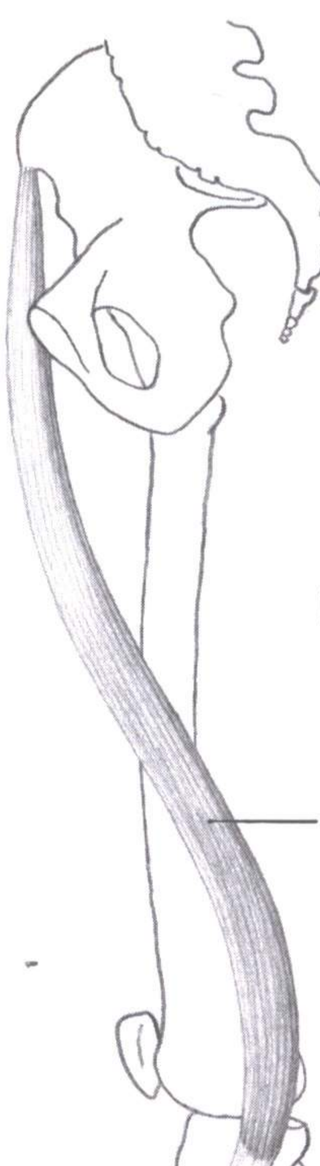
In the front view, the gracilis disappears behind the vastus medialis two-thirds of the way down the thigh.

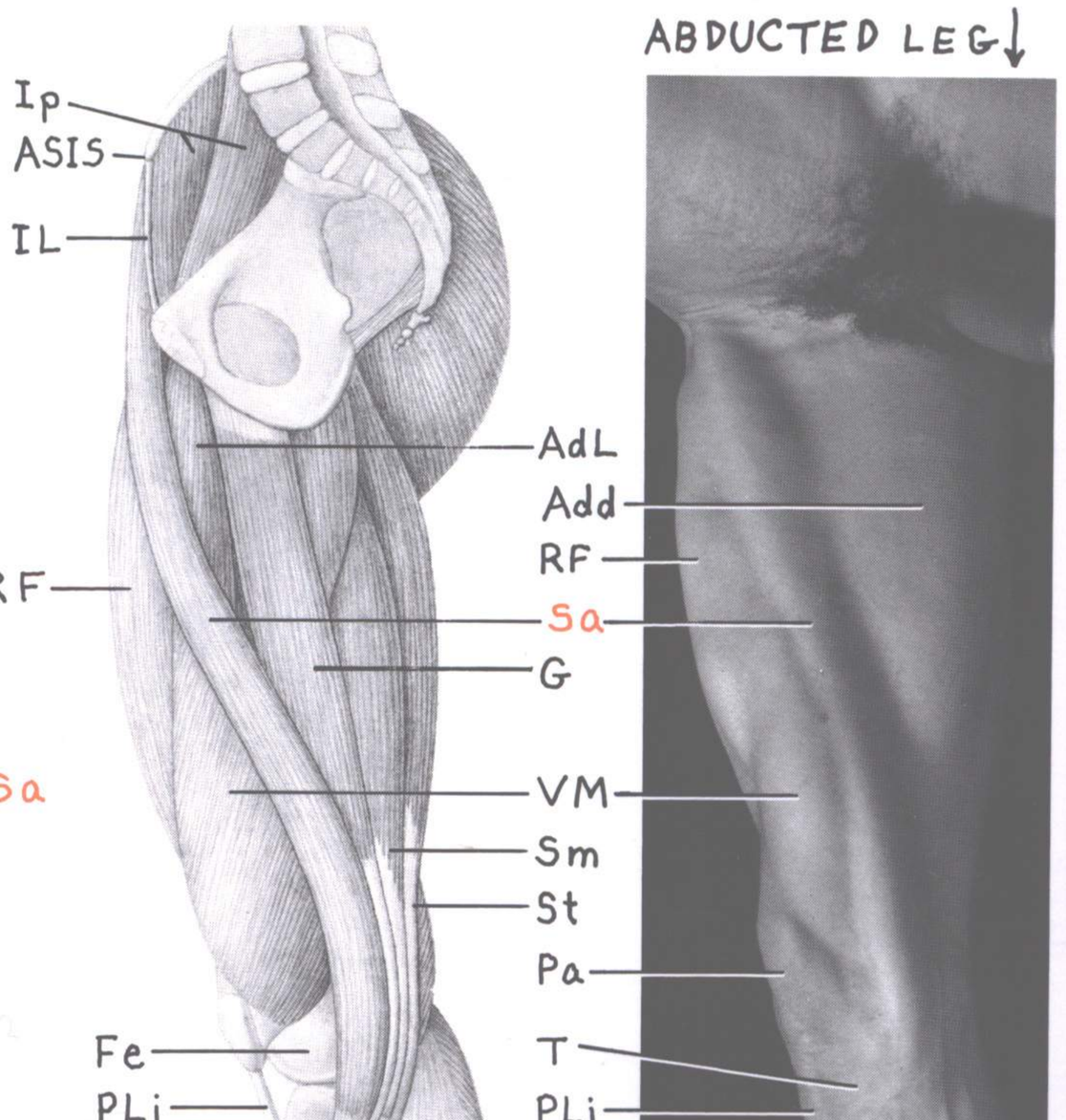




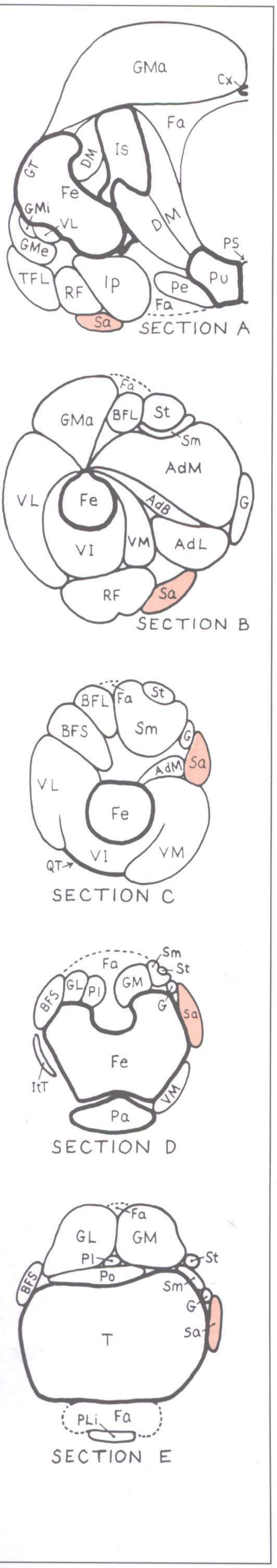








Add *Adductors* **AdL** *Adductor longus* **AdM** *Adductor magnus* **ASIS** *Anterior superior iliac spine*
Fa *Fat* **Fe** *Femur* **G** *Gracilis* **GM** *Gastrocnemius—medial head* **GMe** *Gluteus medius*
IL *Inguinal ligament* **Ip** *Iliopsoas* **Pa** *Patella* **Pe** *Pectineus* **PLi** *Patellar ligament*
RF *Rectus femoris* **Sa** *Sartorius* **Sm** *Semimembranosus* **St** *Semitendinosus* **T** *Tibia*
TFL *Tensor fascia lata* **VM** *Vastus medialis*



Sartorius

ORIGIN Just below the tip of the anterior superior iliac spine ("front point of the pelvis"), in the upper half of the notch between the anterior superior and anterior inferior iliac spines.

INSERTION Superior part of the medial surface of the shaft of the tibia, below the medial condyle, in common with the insertions of the gracilis and semitendinosus.

ACTION Strongly flexes, weakly abducts, and laterally rotates the thigh at the hip joint; flexes the lower leg and then minimally rotates it medially. It is a powerful flexor of the thigh, even though it is narrow, because it lies some distance in front of the hip joint.

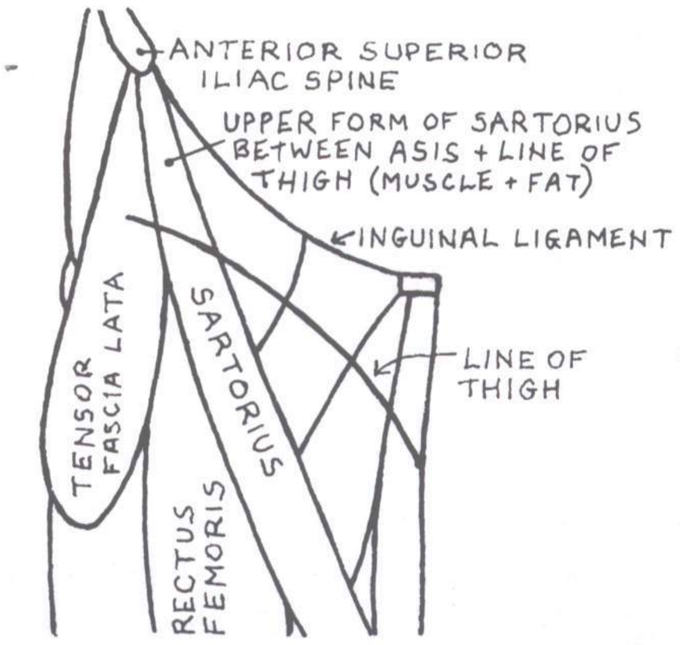
STRUCTURE The sartorius is a long, narrow, thick, ribbonlike muscle that spirals down the thigh. It begins on the front of the hip and ends on the inside of the knee region. It usually sits inconspicuously between the masses of the quadriceps and adductors when the leg is at rest. When the thigh is flexed and laterally rotated at the hip joint, and the knee is also extended, the sartorius becomes prominent as it lifts out of the valley between these bordering muscle masses. Its upper portion lies on the belly of the rectus femoris and is in contact laterally with the tensor fascia lata for a short distance below its origin. The very superior extremity of the sartorius tapers slightly before attaching to the pelvis.

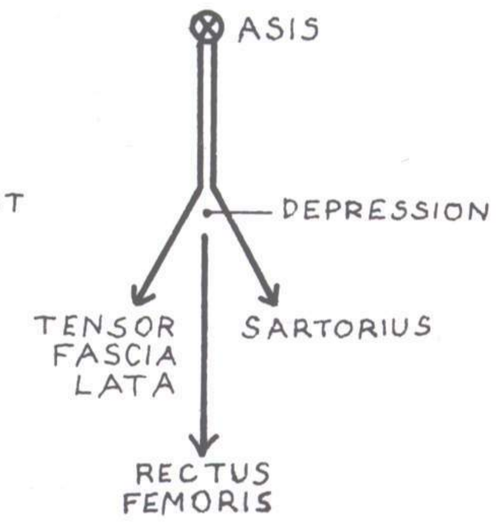
From its origin on the front point of the pelvis, the sartorius passes downward and inward to the medial surface of the thigh. It then descends vertically, hooking behind the vastus medialis. The fleshy fibers end *just below the knee joint on the surface of the medial condyle of the tibia,* and the muscle continues via its flat tendon to its insertion on the shaft of the tibia. This tendon is not visible. The distal fleshy portion of the sartorius adds a muscular fullness to the inside of the knee. From the front view of the thigh, the sartorius is usually not visible as it hooks behind the vastus medialis, but reappears below it on the inside of the knee. When looking at the inside (medial) view of the knee, the anterior edge of the sartorius is on or just posterior to the midline (from the front profile to the back profile of the knee).

As the knee joint is flexed, the sartorius gets shorter and thicker. When the knee is completely flexed, it either merges with the bulging form of the adductor muscles or creates its own wide form on the medial surface of the thigh. In this position, a skin flexion fold develops on the back of the knee and cuts across the distal end of the sartorius. Also during knee flexion, the lower portion of the belly of the sartorius moves posteriorly and away from the distal end of the vastus medialis, and a slight depression forms between the two muscles on the inside surface of the knee region.

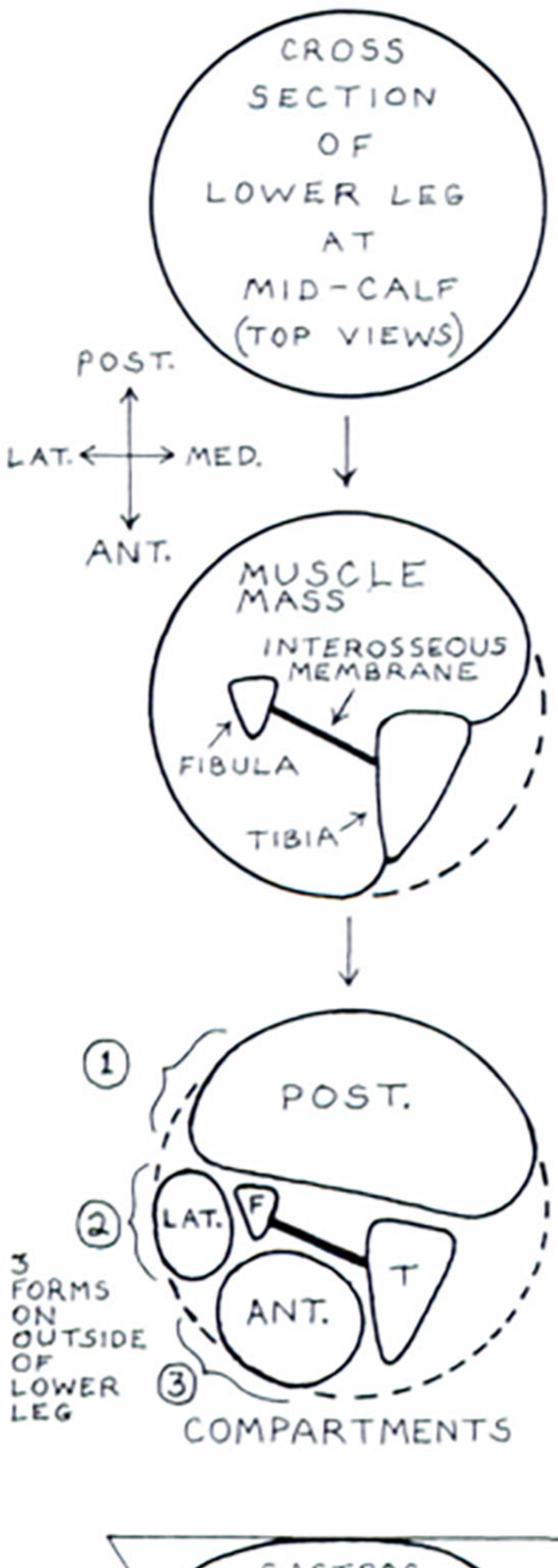
The upper end of the sartorius, located between the anterior superior iliac spine and the line of the thigh (genital fold), joins with the fat of this region to form a short, narrow, independent form in the extended hip joint.

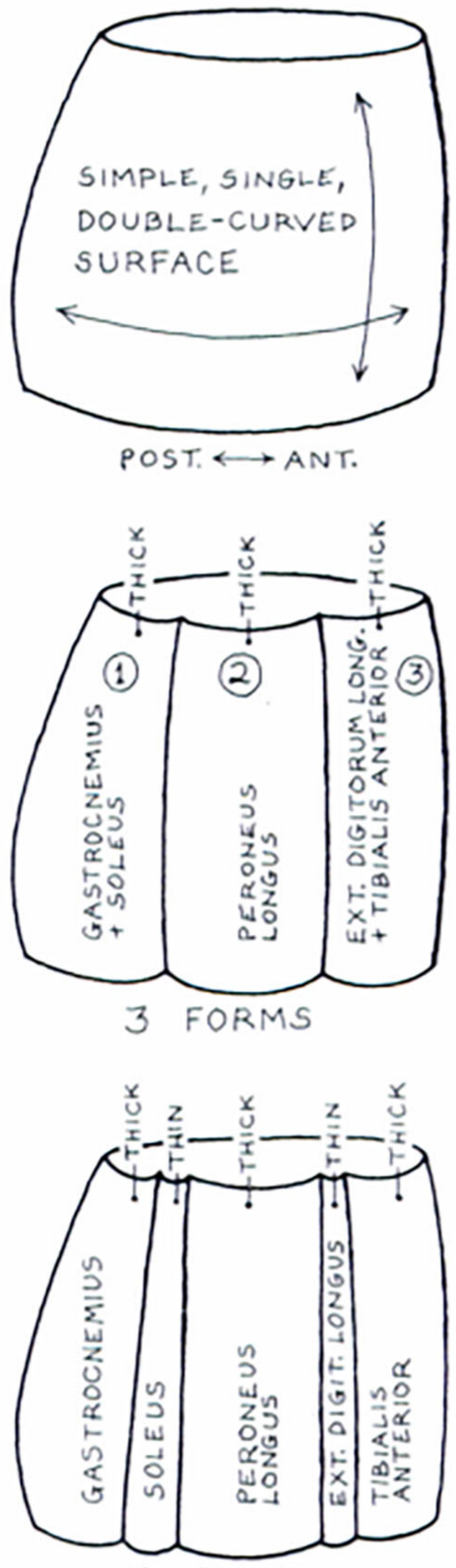
The **pes anserinus** is a flattened aponeurosis made up of the combined inserting distal ends of the tendons of the sartorius, semitendinosus, and gracilis. It does not create any form on the surface, and the form of the tibia predominates.

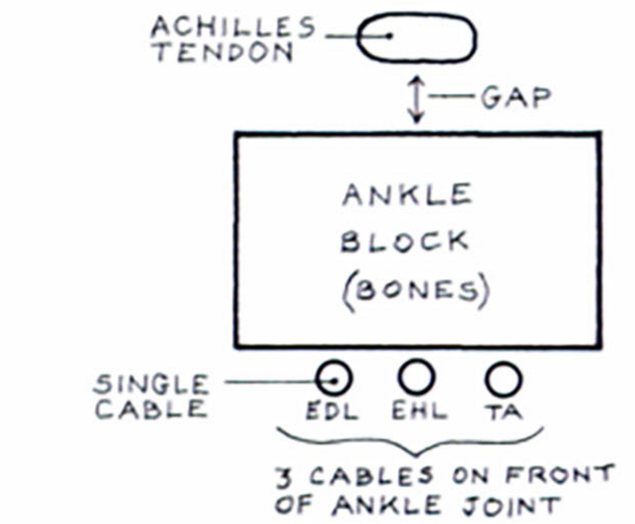


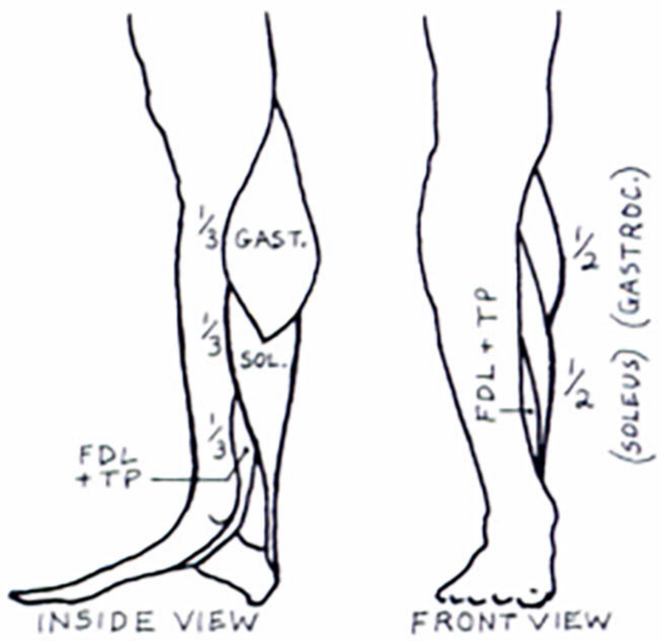


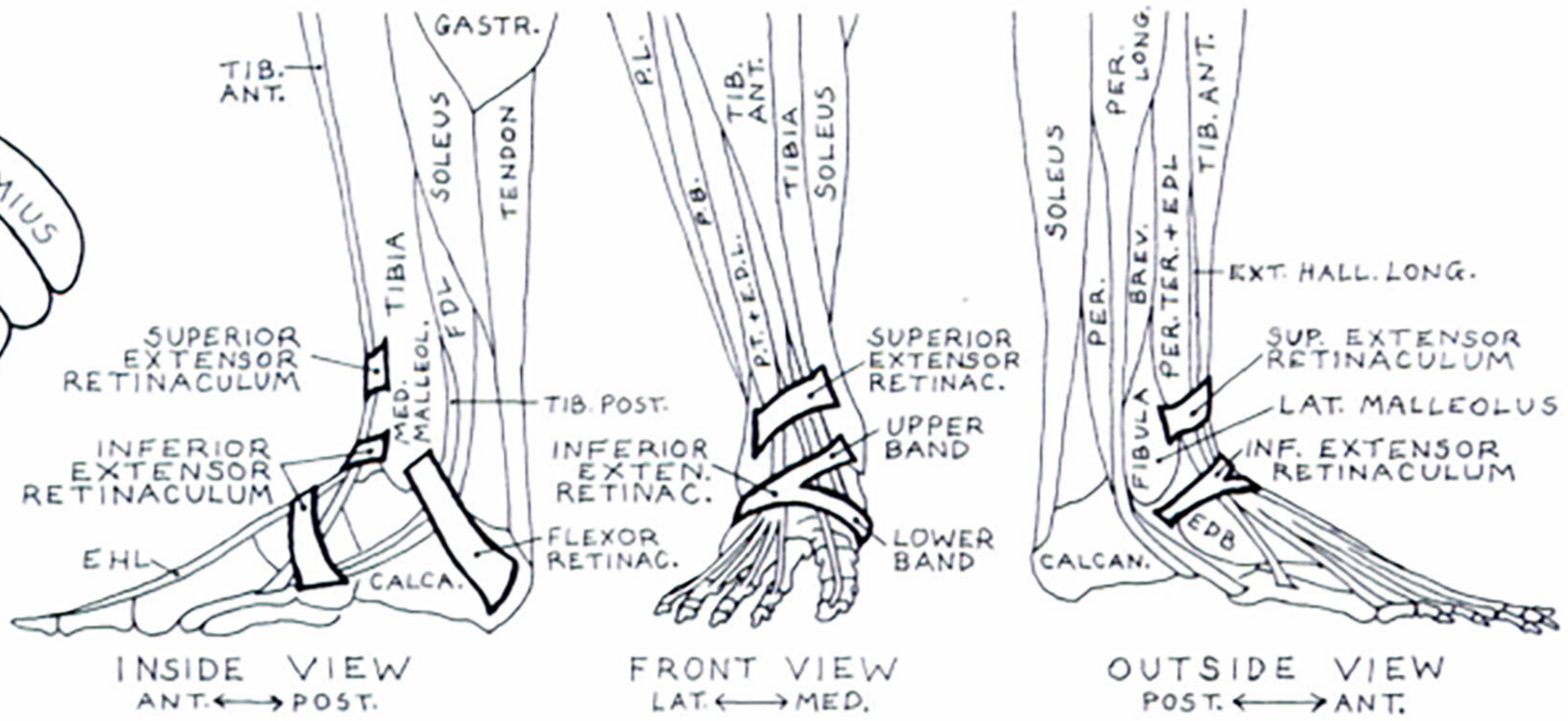
The Lower Leg Muscles











AT *Achilles tendon* **EDB** *Extensor digitorum brevis* **EDL** *Extensor digitorum longus*
EHL *Extensor hallucis longus* **F** *Fibula* **FDL** *Flexor digitorum longus* **PB** *Peroneus brevis*
PL *Peroneus longus* **PT** *Peroneus tertius* **T** *Tibia* **TA** *Tibialis anterior* **TP** *Tibialis posterior*

The Lower Leg Muscles

The muscles of the *LOWER LEG* attach to and move the foot. They cross the ankle joint and are referred to as the **extrinsic muscles of the foot.** Except for the gastrocnemius, which originates from the femur, the muscles of the lower leg originate from the two lower leg bones and the intervening interosseous membrane. The lower leg is also referred to as the **crus.**

The lower leg can be divided into three portions or compartments. The **anterior portion** consists of the tibialis anterior, extensor digitorum longus, peroneus tertius, and extensor hallucis longus. The tendons of these muscles pass downward on the *front* of the ankle joint. The tendons of the extensor digitorum longus combine into a single cable on the front of the ankle. This cable also includes the tendon of the peroneus tertius.

The **posterior portion,** which is the largest, is made up primarily of the calf muscles. These muscles are collectively called the **triceps surae** and consist of the two-headed gastrocnemius and soleus. Their strong, combined tendon, the Achilles tendon, lies *behind* the bones of the ankle joint and is separated from them by a small interval. The tibialis posterior, flexor digitorum longus, and flexor hallucis longus are also part of the posterior group. The tendon of the tibialis posterior is subcutaneous and lies against the posterior surface of the medial malleolus. The anterior and posterior muscle groups are antagonists that alternately lift and then point the foot (dorsiflex and plantar flex), like an upside-down seesaw whose fulcrum is the ankle joint.

The **lateral portion** consists of the peroneus longus and brevis. Their tendons hook *behind* the lateral malleolus, and they point the foot. At the ankle, the peroneus longus tendon lies posterior to and on top of the peroneus brevis tendon.

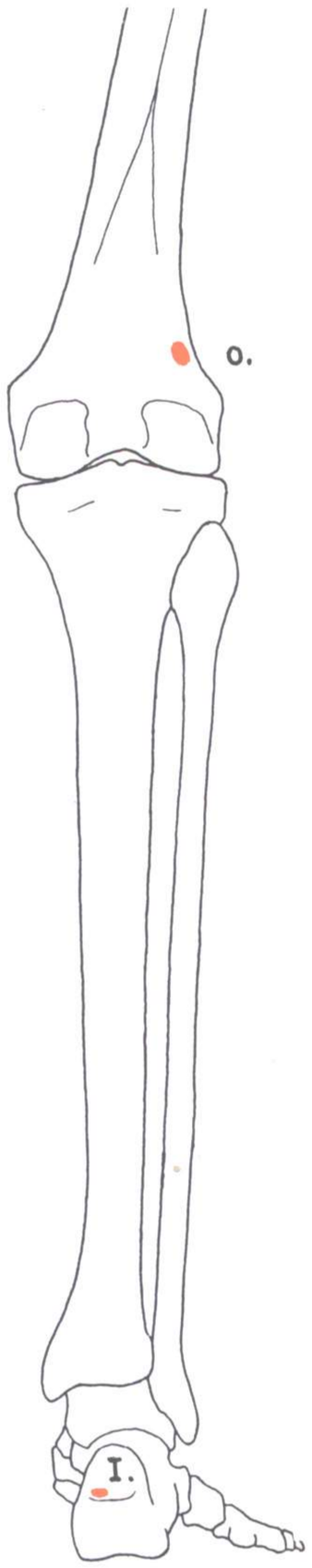
The muscles whose tendons lie toward the *inside* of the ankle joint (tibialis anterior and posterior) will **invert** the foot, regardless of the compartment of origin of their belly. Likewise, the tendons lying toward the *outside* of the ankle will **evert** the foot (peroneus longus and brevis, extensor digitorum longus, peroneus tertius).

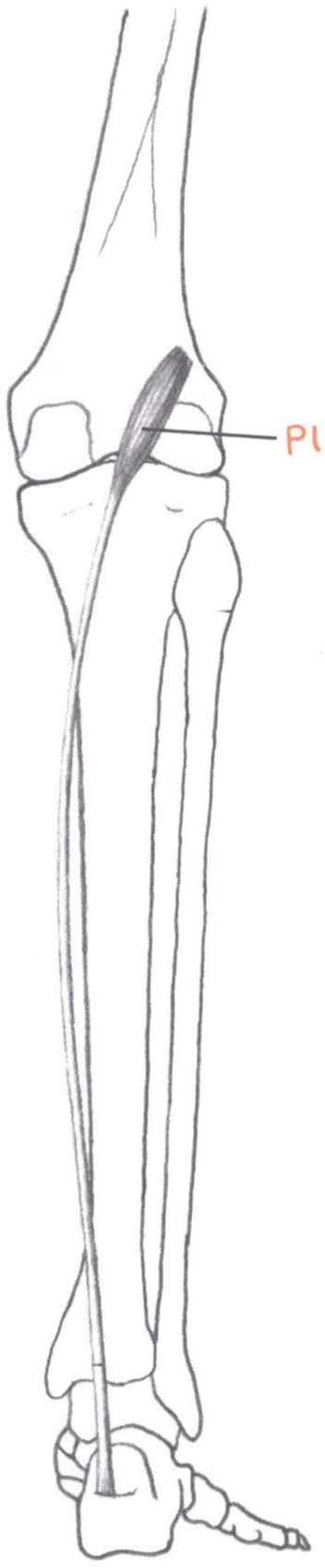
The inside view of the lower leg is roughly divisible into thirds from top to bottom. Two relatively strong forward curves are produced by the gastrocnemius and soleus where their bellies meet the tibia, on the upper and middle thirds of the lower leg, respectively. The flexor digitorum longus occupies the lower third of the inside of the lower leg; its subtle form is never prominent.

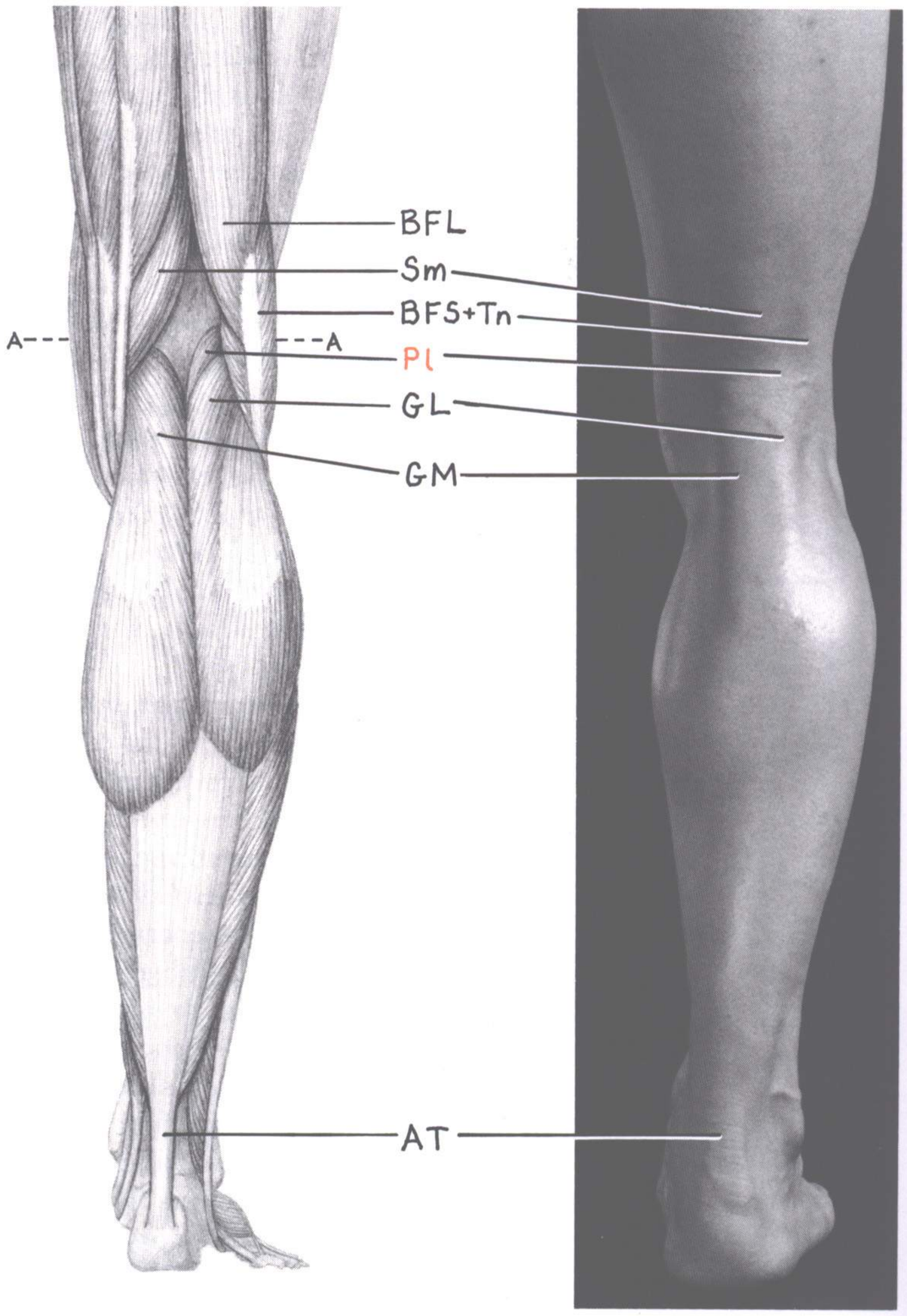
Looking at the muscles of the upper portion of the lower leg from the outside view, and proceeding from front to back, they alternate in size, beginning thick (tibialis anterior), then thin (extensor digitorum longus), then thick (peroneus longus and brevis), then thin (soleus), and lastly thick (gastrocnemius). In life, the forms of the tibialis anterior and extensor digitorum longus usually blend together, and the soleus and gastrocnemius also often blend together, although less so than the first two. This blending simplifies the outside of the lower leg into three large forms. When there is no muscle definition on the lower leg, its surface presents a simple, smooth, double curve.

In the ankle region, the tendons of the lower leg are bound to the leg by thick, fibrous, strap-like bands, called **retinacula.** They prevent the tendons from pulling away from the leg when their muscles are contracted. The retinacula are usually not visible; however, portions of the inferior extensor retinaculum may occasionally be seen.

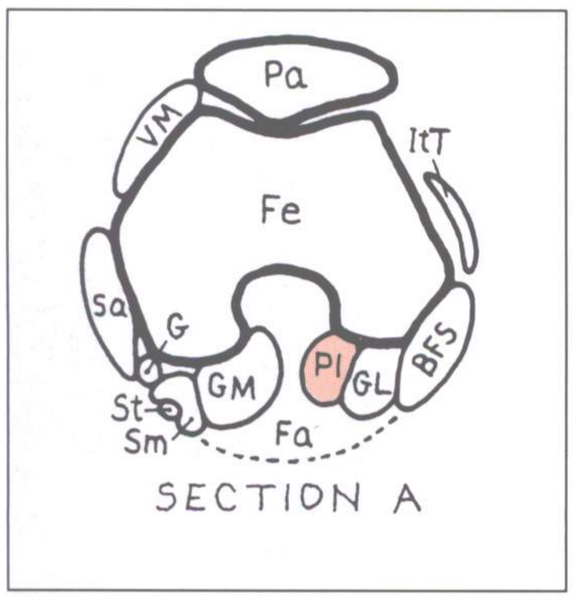
The cross section of the muscular upper region of the lower leg can be represented initially by a circle and then modified into a more appropriate triangular shape, its apex directed anteriorly. The knee above, and the bones of the ankle below, are square and blocklike. The knee is wider in back and narrower in front.







AT *Achilles tendon* **BFL** *Biceps femoris—long head* **BFS** *Biceps femoris—short head* **Fa** *Fat* **Fe** *Femur* **GL** *Gastrocnemius—lateral head* **GM** *Gastrocnemius—medial head* **Pl** *Plantaris* **Sm** *Semimembranosus* **Tn** *Tendon*



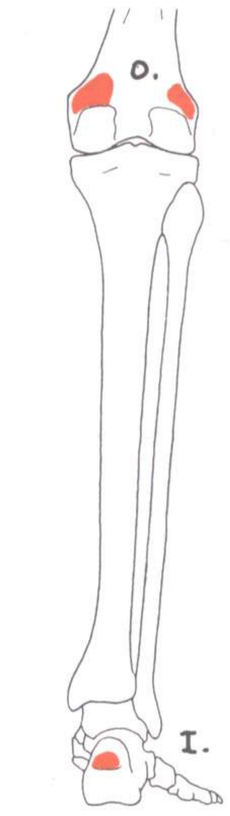
Plantaris

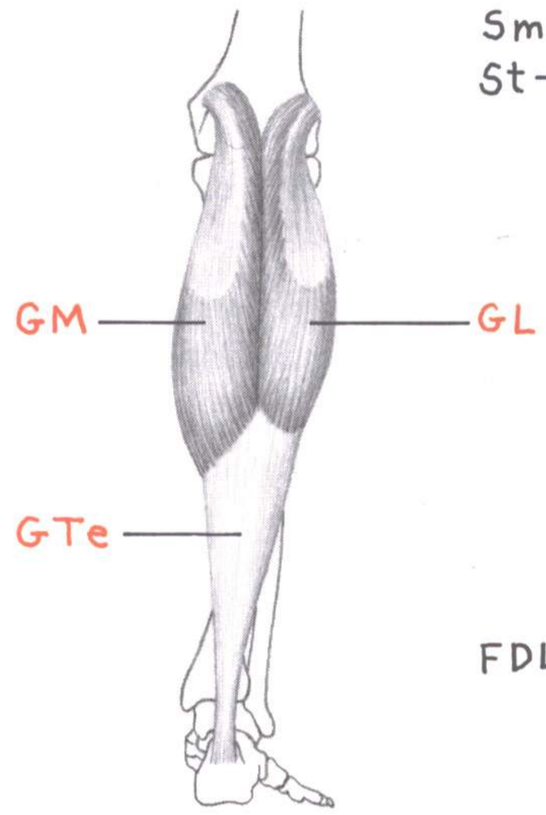
ORIGIN Lower end of the lateral supracondylar ridge of the femur, just above the lateral condyle (immediately above the origin of the lateral head of the gastrocnemius).

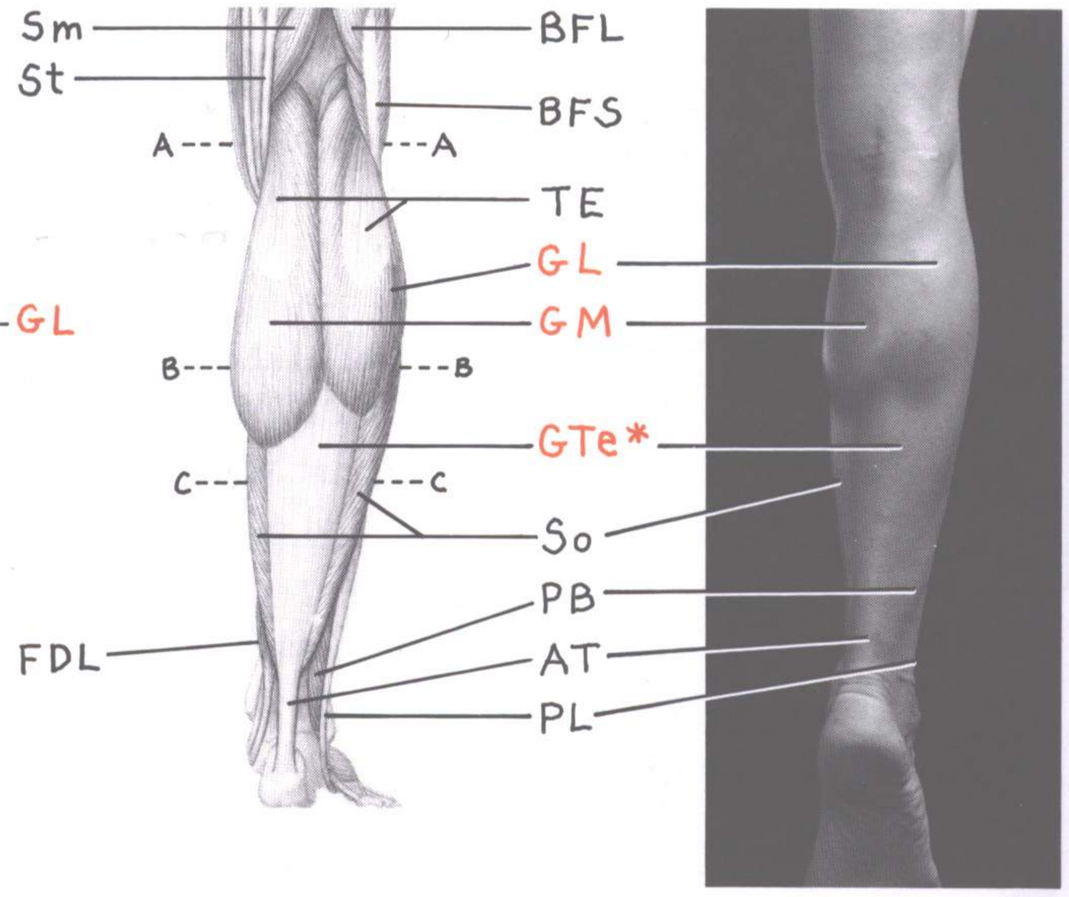
INSERTION Very small area on the posterior surface of the calcaneus, medial to the insertion of the Achilles tendon.

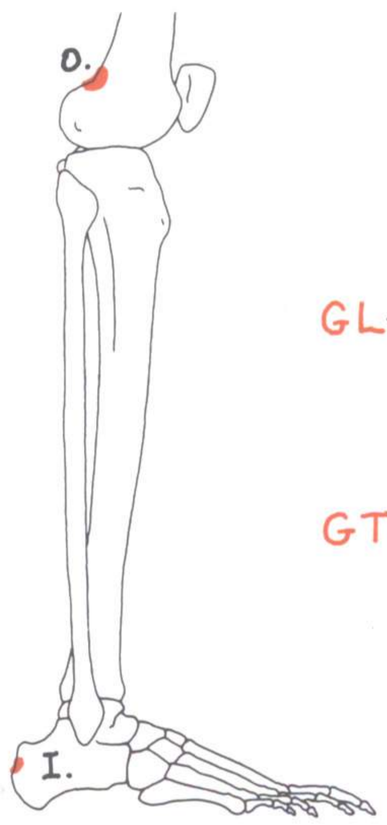
ACTION Weak action of flexion of the knee joint and plantar flexion of the foot.

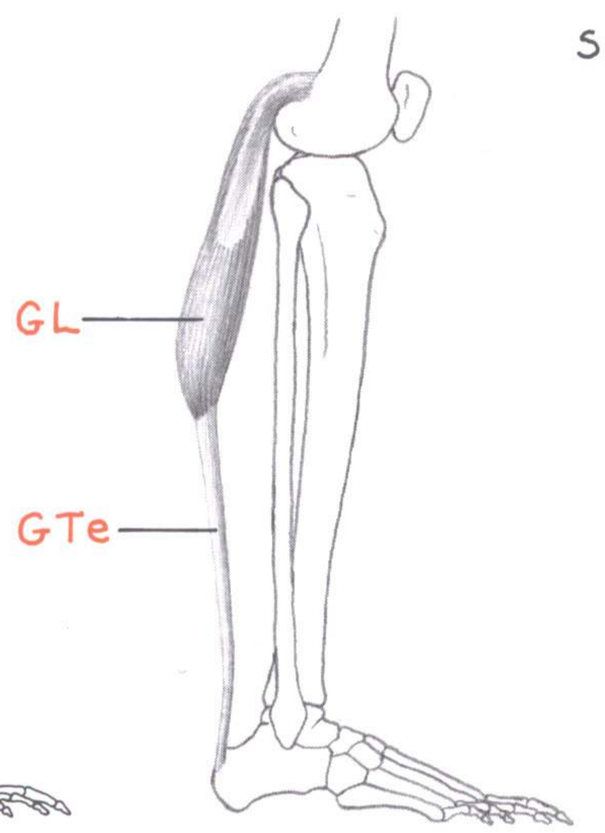
STRUCTURE The belly of the plantaris is slender, short, and fusiform; it contributes only slightly to the muscular column of the lateral head of the gastrocnemius. Its extremely long, thin tendon at first lies deep between the soleus and gastrocnemius and then emerges on the medial side of the Achilles tendon. This tendon is too thin to be seen on the surface, but when the knee is partly flexed, the foot plantar flexed, and pressure is placed against the heel, part of the muscle belly of the plantaris may be seen on the back of the bent knee, just lateral to the midline.

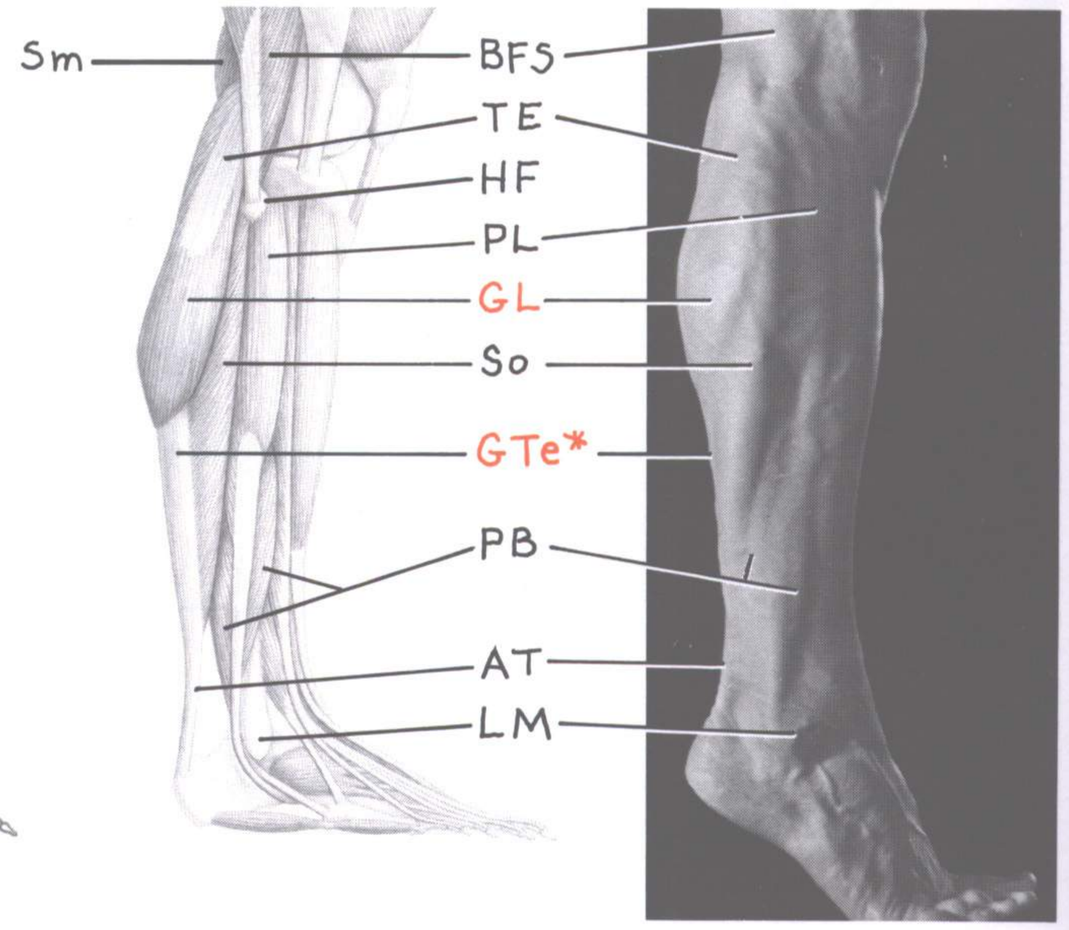


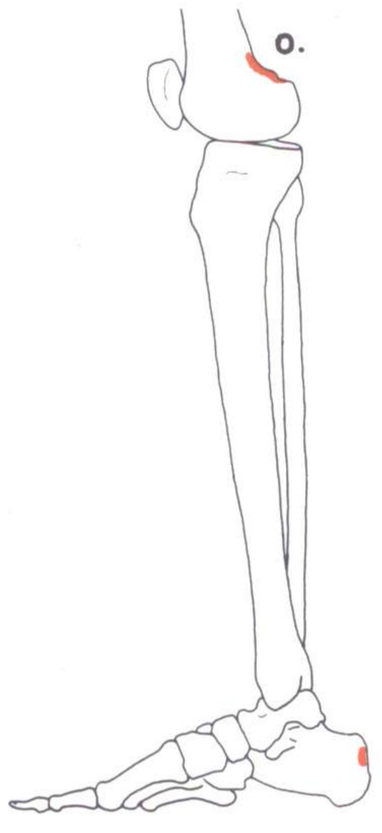


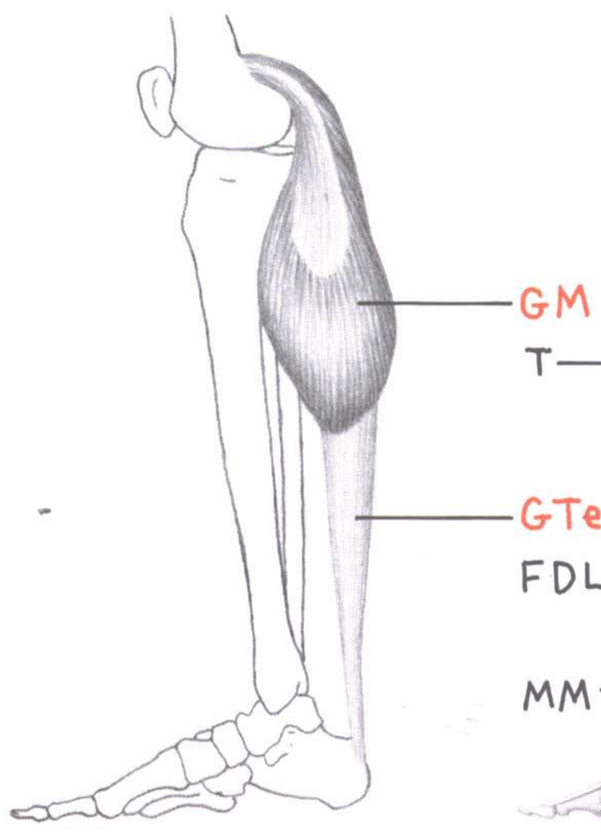


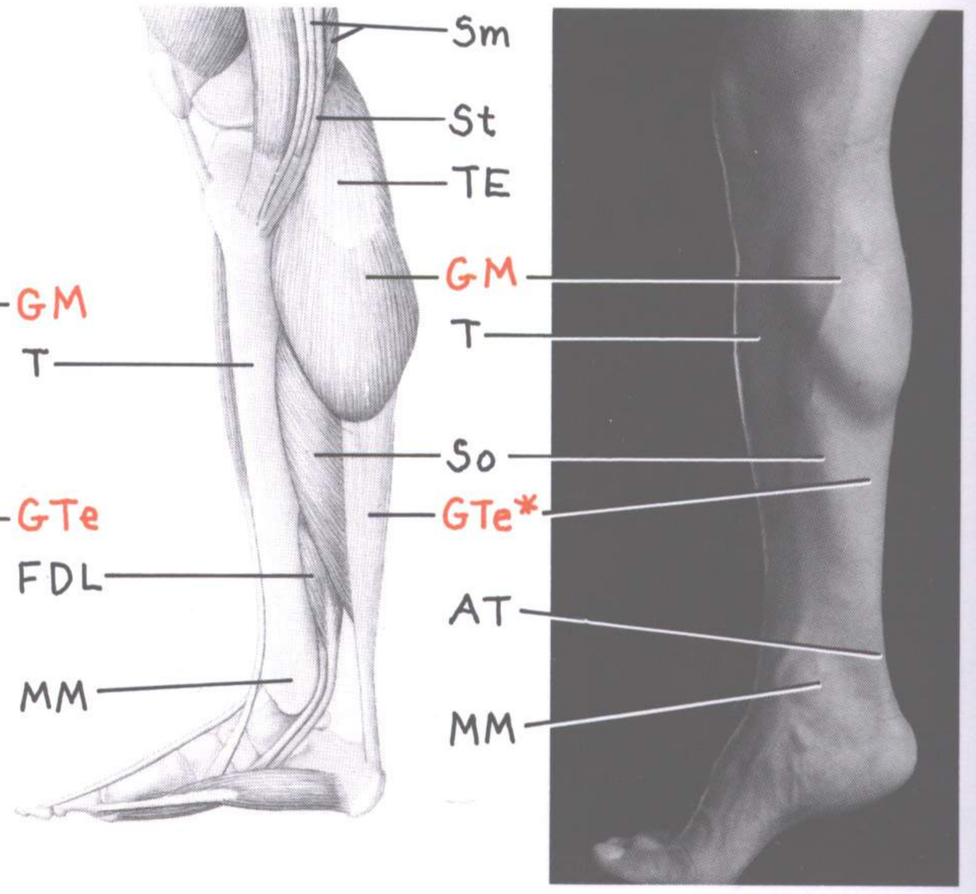




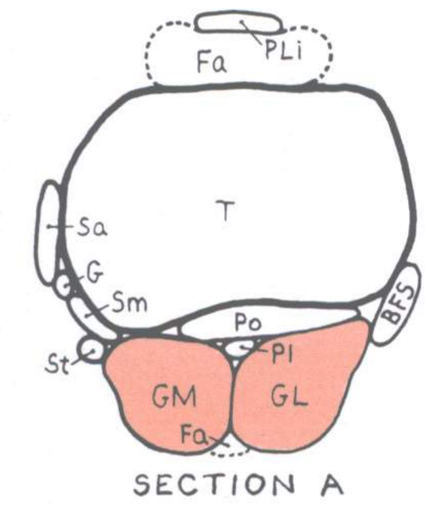








AT *Achilles tendon* **BFL** *Biceps femoris—long head* **BFS** *Biceps femoris—short head* **F** *Fibula*
Fa *Fat* **FDL** *Flexor digitorum longus* **GL** *Gastrocnemius—lateral head*
GM *Gastrocnemius—medial head* **GTe** *Gastrocnemius tendon* **HF** *Head of fibula*
LM *Lateral malleolus* **MM** *Medial malleolus* **PB** *Peroneus brevis* **PL** *Peroneus longus* **Pl** *Plantaris*
Po *Popliteus* **Sm** *Semimembranosus* **So** *Soleus* **St** *Semitendinosus* **T** *Tibia*
TE *Tendinous expansion* * *On soleus*



Gastrocnemius

ORIGIN *Lateral head:* A facet on the lateral side of the lateral condyle of the femur and the posterior surface of the shaft immediately above this area. *Medial head:* A facet on the upper part of the medial condyle of the femur and the adjacent roughened area above it.

INSERTION Middle part of the posterior surface of the calcaneus, in common with the soleus (the insertion of the Achilles tendon).

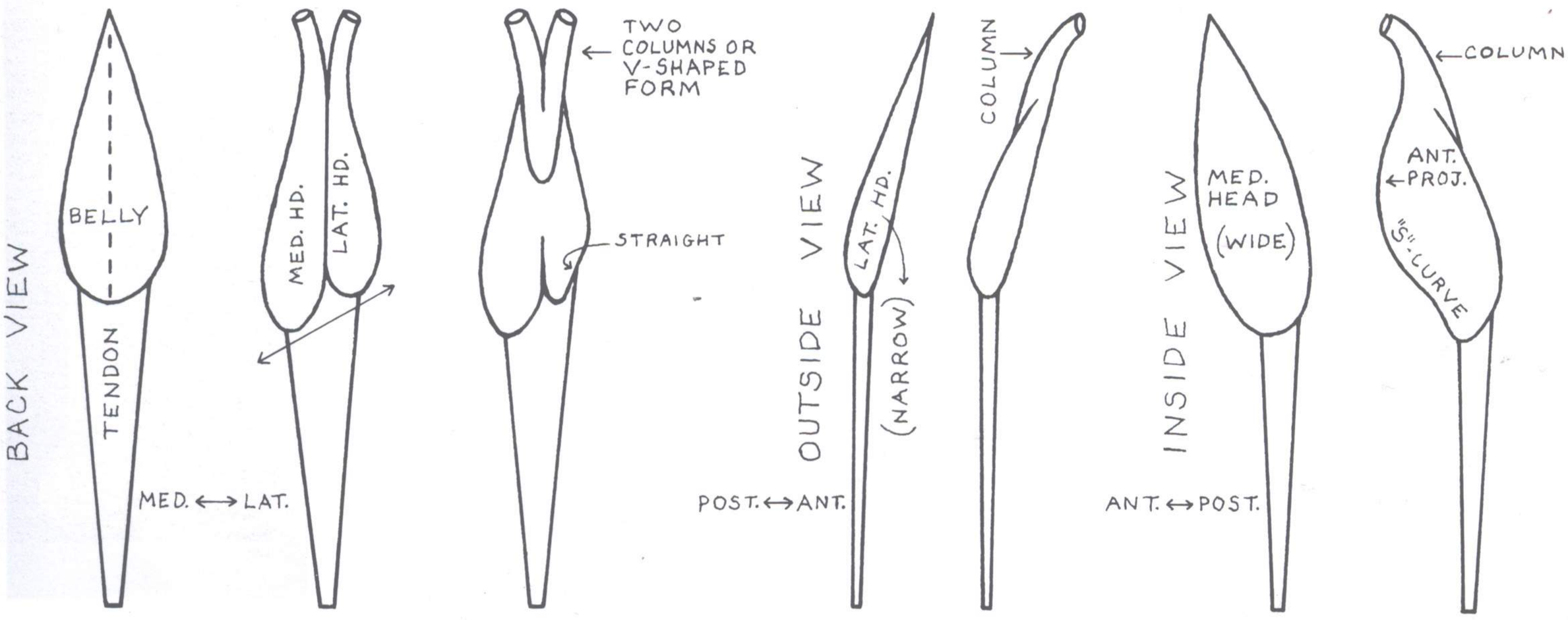
ACTION *Foot free:* Plantar flexes the foot (points the foot). *Foot on ground:* Raises the heel, which lifts the body. The gastrocnemius may assist minimally in flexing the knee joint. It will *not* plantar flex the foot when the knee is completely flexed (because it is then actively insufficient).

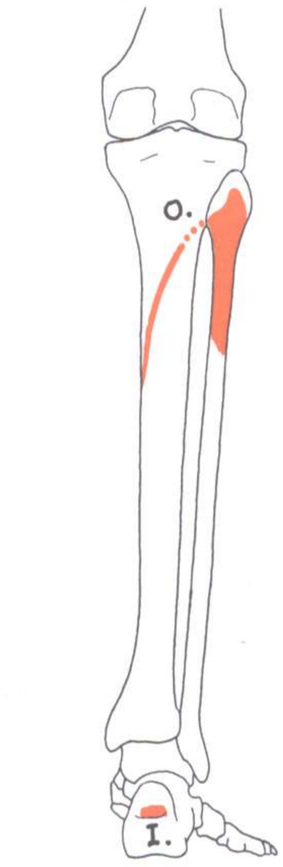
STRUCTURE The gastrocnemius is made up of a lateral head, a medial head, and their single tendon of insertion. The medial head is larger, descends lower, and wraps around the leg more toward the front than does the lateral head. The lower lateral edge of the lateral head may be an oblique straight line, rather than a rounded teardrop. The muscular heads end at, or slightly above, the middle of the leg, where they attach to their tendon. The tendon is wide and thin at its upper end and becomes narrower and thicker as it descends. It fuses with the tendon of the soleus lying immediately deep to it, forming the *Achilles tendon* (see Soleus).

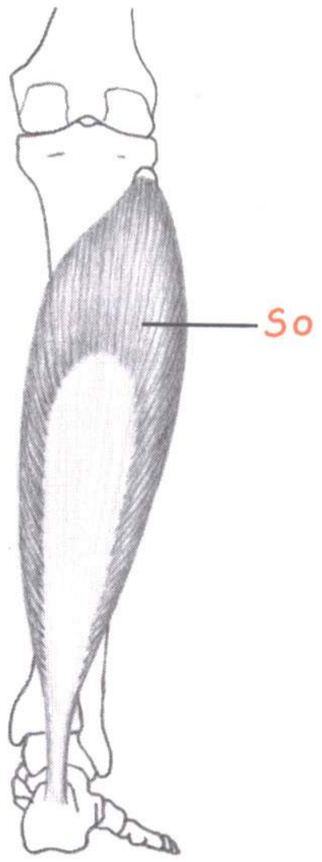
From its origin, each head begins as a thick, rounded, muscular column, separated from its fellow at the back of the knee. They soon come together, with a cleft between them that usually disappears at the middle of the belly. When the muscle is tensed, the columns separate from the rest of the head. Together they form a raised, thick, fleshy V on the back of the calf. The medial column is more vertical, the lateral more oblique and sometimes larger.

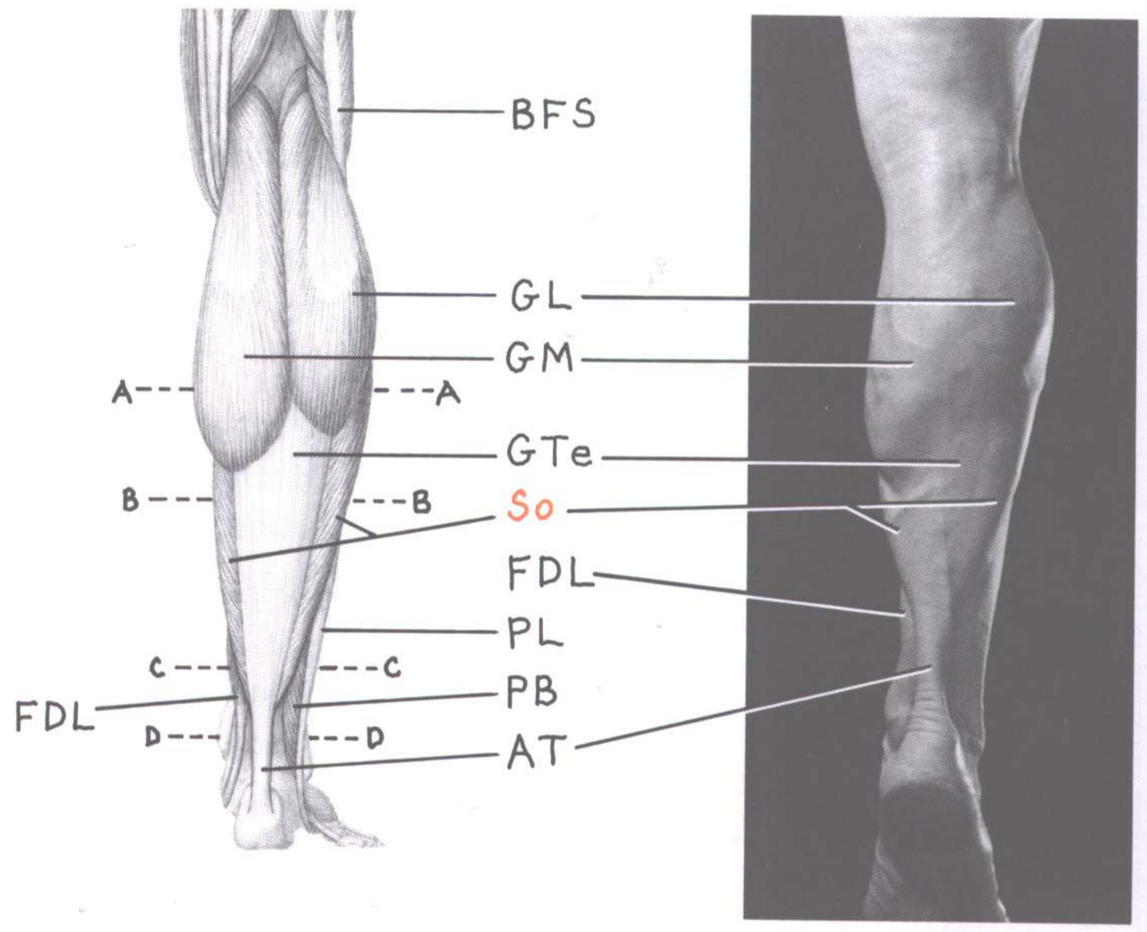
The separation of the muscular column from the rest of the head is caused by an aponeurotic sheet of tendon that begins at the origin of each head at the femur and expands downward onto the posterior surface of the upper portion of each head. This nonelastic tendinous sheet does not cover the column, and when the gastrocnemius contracts, it prevents the fleshy muscle mass immediately deep to it from expanding, but allows the exposed muscular column to bulge. The area of muscle restricted by the aponeurosis appears flat and planar in the contracted muscle. A sharp furrow may separate the column from the flat, tendon-covered area.

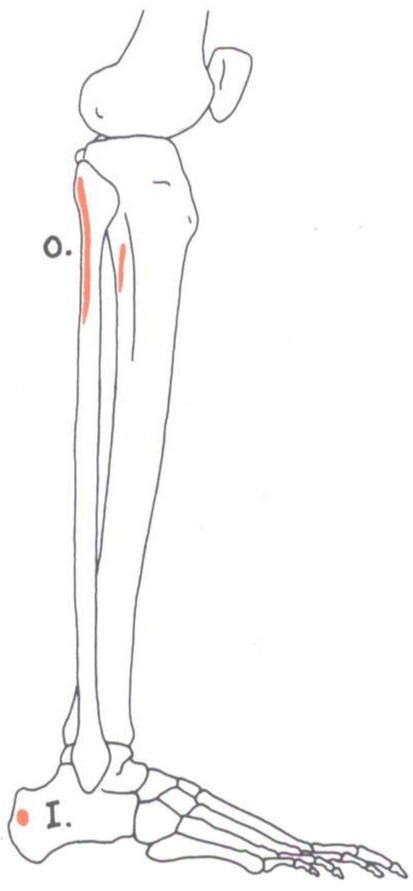
From the side view (medial or lateral), the posterior profile of the gastrocnemius is seen as a convex double curve—the muscular columns bulging above, the remainder of the heads below. In front view, the inside profile of the medial head is directed toward the center of the patella. From the inside view, the lower edge of the medial head ranges from a simple downward curve or a straight line to an S curve.

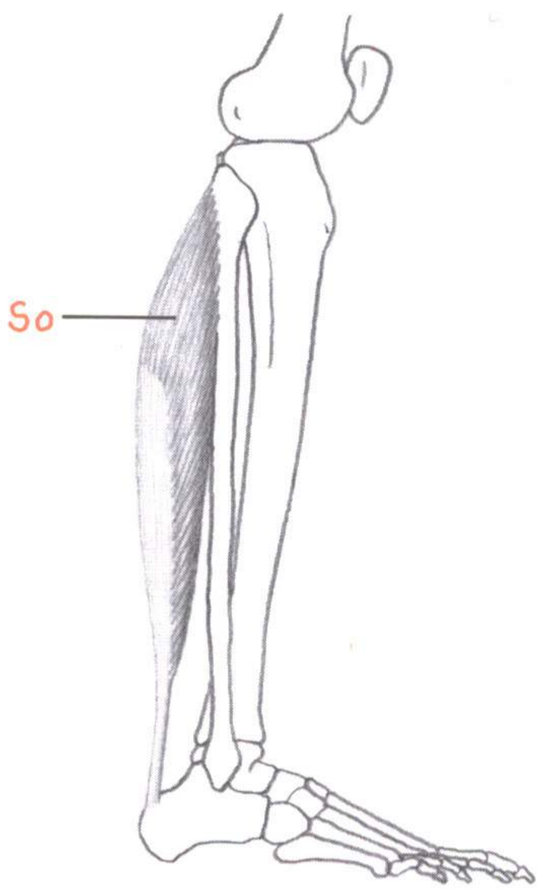


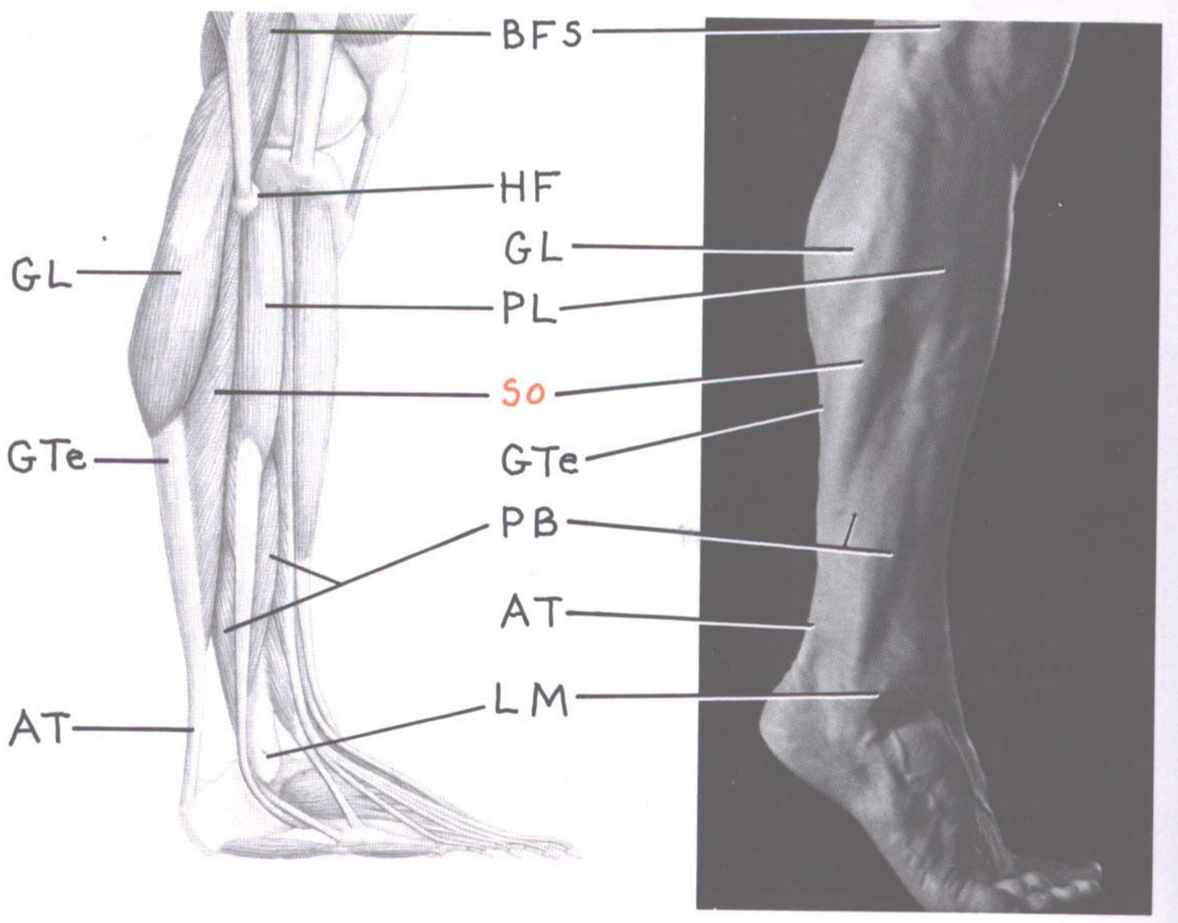


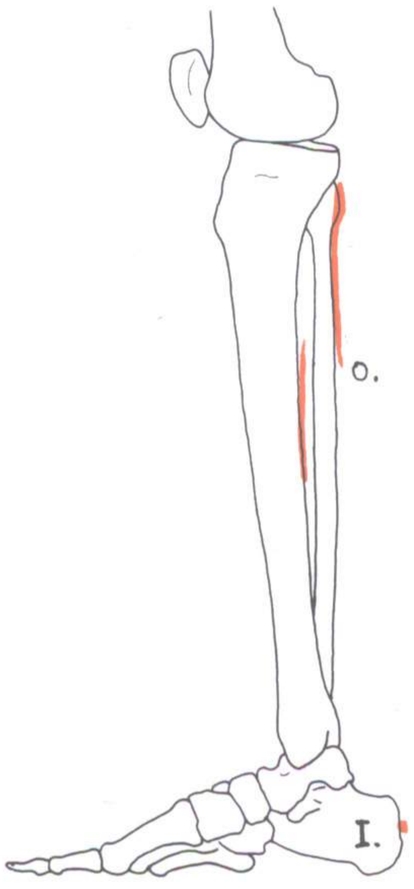


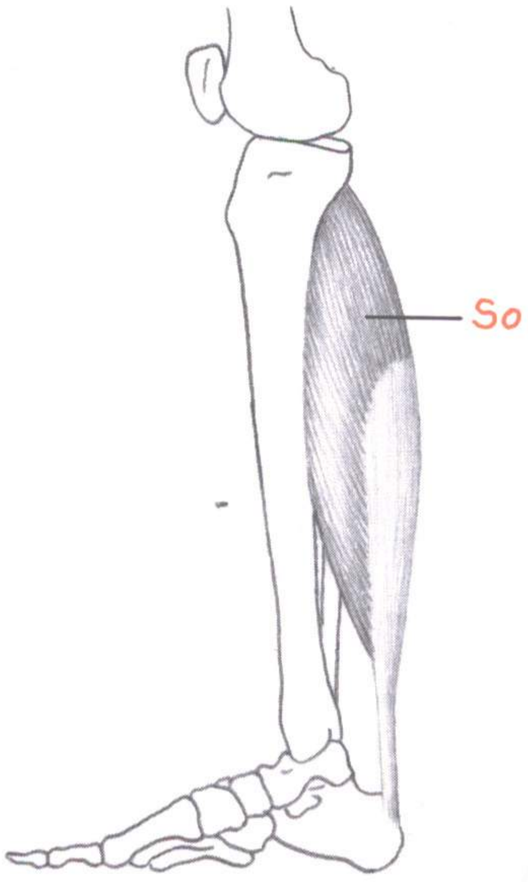


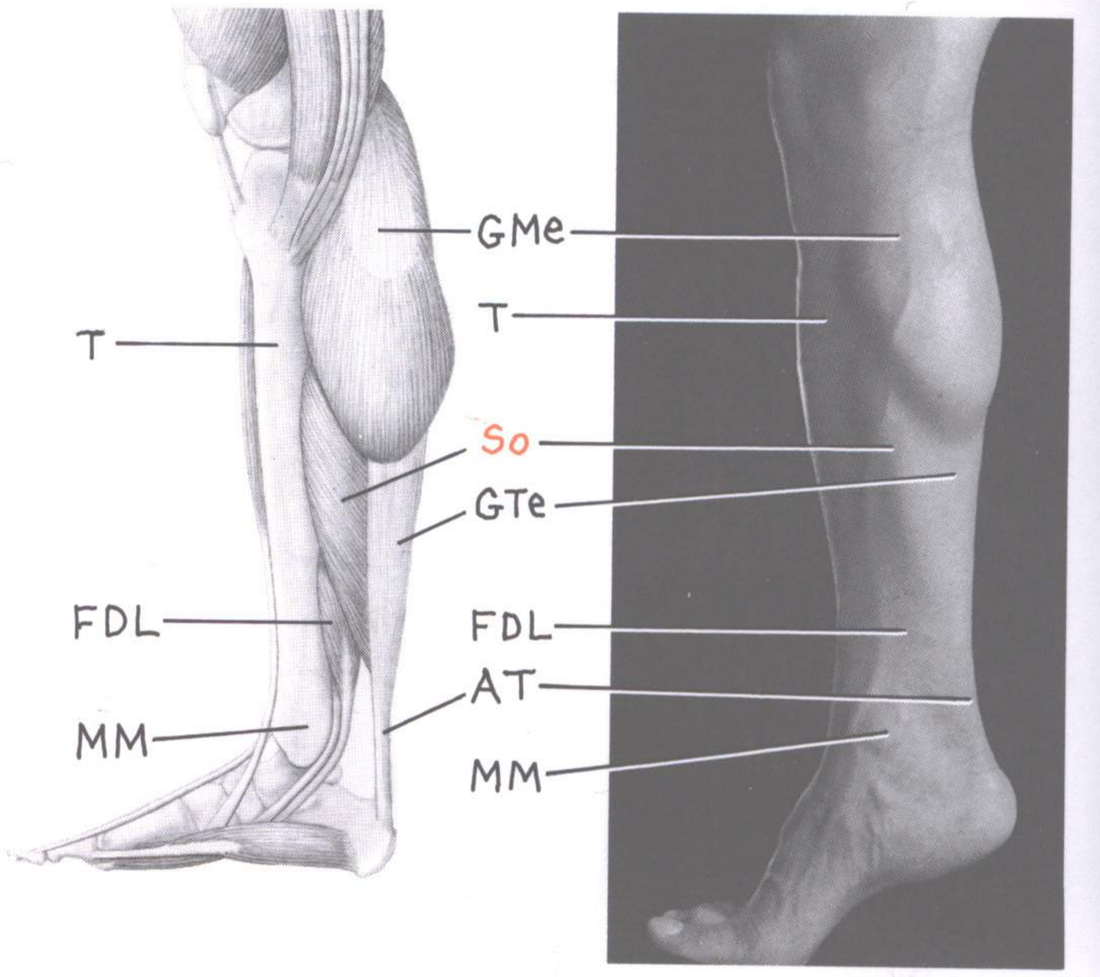




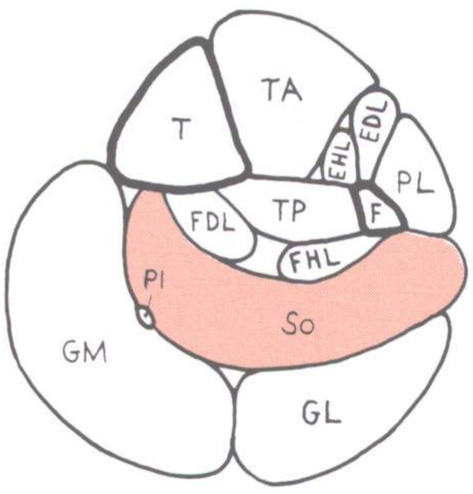




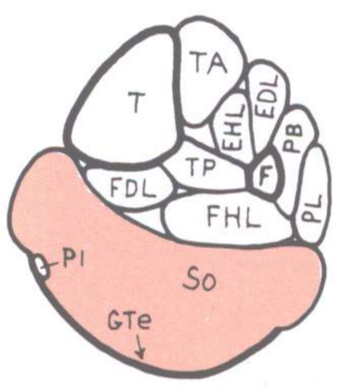




AT *Achilles tendon* **BFS** *Biceps femoris—short head* **F** *Fibula* **Fa** *Fat* **FDL** *Flexor digitorum longus* **FHL** *Flexor hallucis longus* **GL** *Gastrocnemius—lateral head* **GM** *Gastrocnemius—medial head* **GTe** *Gastrocnemius tendon on soleus* **HF** *Head of fibula* **LM** *Lateral malleolus* **MM** *Medial malleolus* **PB** *Peroneus brevis* **PL** *Peroneus longus* **Pl** *Plantaris* **So** *Soleus* **T** *Tibia*



SECTION A



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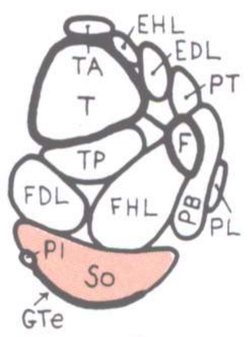

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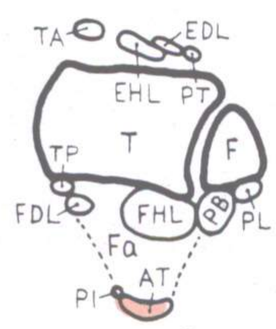


SECTION D

Soleus

ORIGIN Posterior surfaces of the head and upper third of the shaft of the fibula; from a tendinous arch connecting the head of the fibula to the tibia; and from the raised *soleal line* on the back of the tibia. The tendinous arch is continuous with the soleal line.

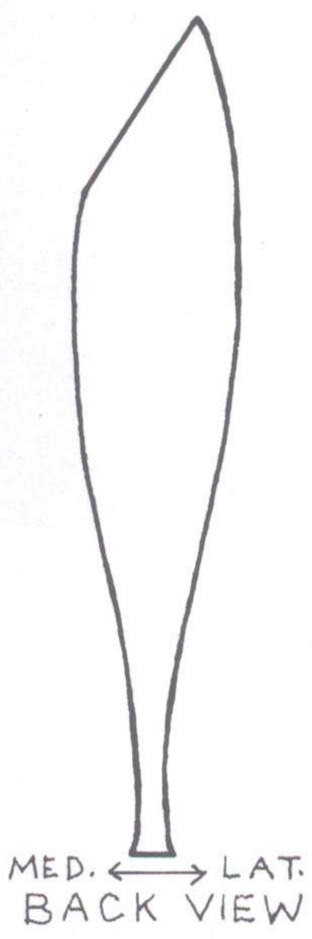
INSERTION Middle part of the posterior surface of the calcaneus, in common with the gastrocnemius (the insertion of the Achilles tendon).

ACTION *Foot free:* Plantar flexes the foot (points the foot). *Foot on the ground:* Raises the heel, which lifts the body, and by continuous contraction, prevents the body from falling forward in the standing position.

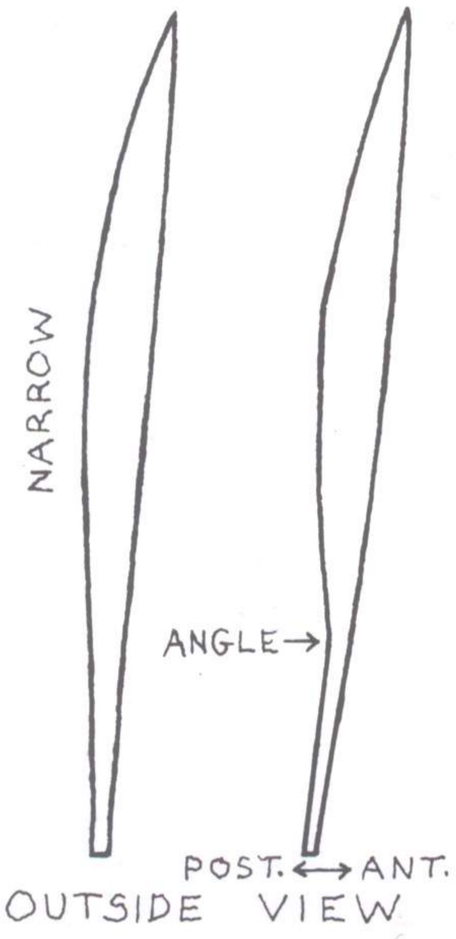
STRUCTURE The soleus is a thick muscle located on the back of the lower leg; it joins the gastrocnemius to form the calf muscle group. It is thickest at its middle, where its flattened form curves around the deep flexor muscles of the foot and toes. The medial side of the belly projects more anteriorly (on the inside of the lower leg) than does the lateral side. Its upper portion is covered by the heads of the gastrocnemius.

The muscle mass of the soleus tapers inferiorly and descends quite low, reaching a level just above the ankles. Its tendon, which continues on to its insertion on the heel, begins quite high on the posterior surface of the belly. It soon fuses with the overlying gastrocnemius tendon, and this combined tendon from mid-leg downward is called the **Achilles tendon** (tendo calcaneus). This flattened tendon is narrowest (about three-fourths of an inch) and most prominent (most defined) at the level of the lateral malleolus. It widens slightly before it inserts. There is a fat-filled interval between the Achilles tendon and the back of the ankle bones. The medial and lateral edges of the combined tendons of the soleus and gastrocnemius, lying on the belly of the soleus, may compress the soleus and create two vertical furrows when the calf muscles are contracted. The form of the soleus is then divided into three vertical muscular columns: two narrow columns on either side of the edges of the tendon and a wide, raised relief up the middle of the muscle between the edges.

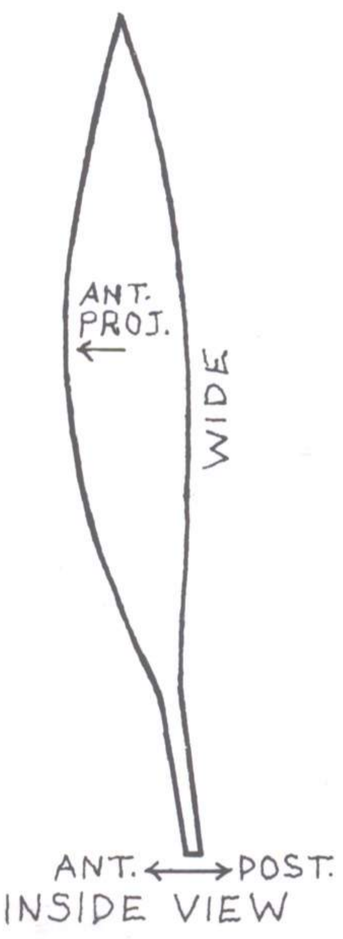
In side view, the back profile of the muscular belly of the soleus is either straight or only slightly convex. It meets the Achilles tendon at a slight angle, and below this angle the profile appears as a straight line when the calf is tensed or as a subtle concave line when relaxed (usually with the foot partly plantar flexed). After the tendon inserts, the bony calcaneus of the heel bulges posteriorly, and a second bulge below the calcaneus is created by the fat pad under the heel. In the front or rear view, the soleus often forms the profile on the outer side of the upper half of the lower leg (the peroneus brevis forms the profile on the lower half). The medial side of the belly can be seen on the middle third of the lower leg from the front view.



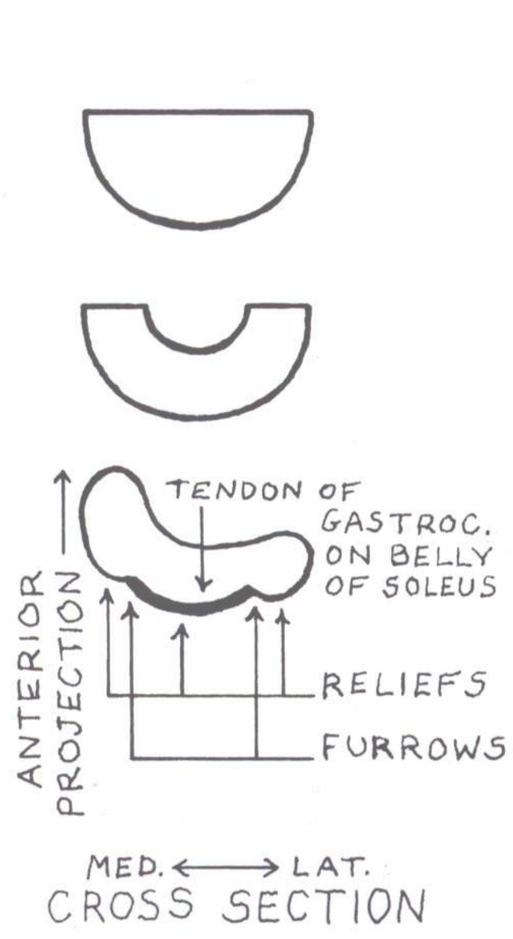
BACK VIEW



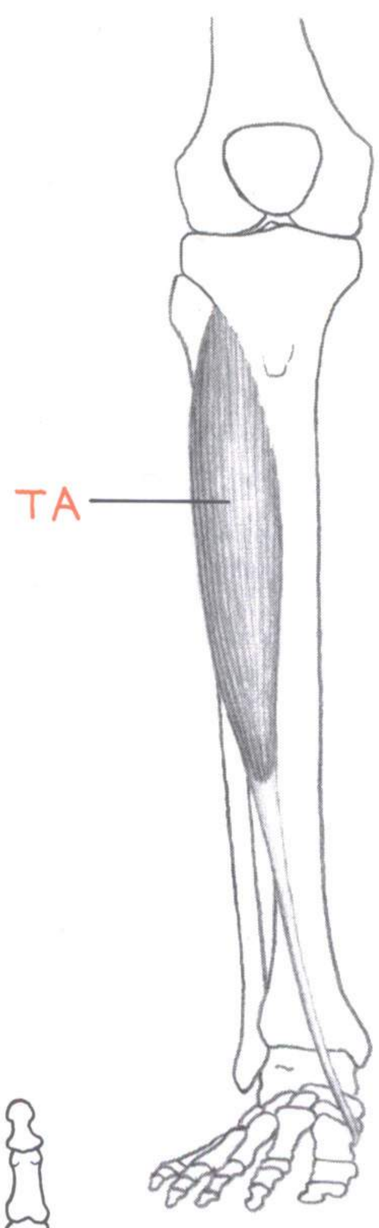
OUTSIDE VIEW

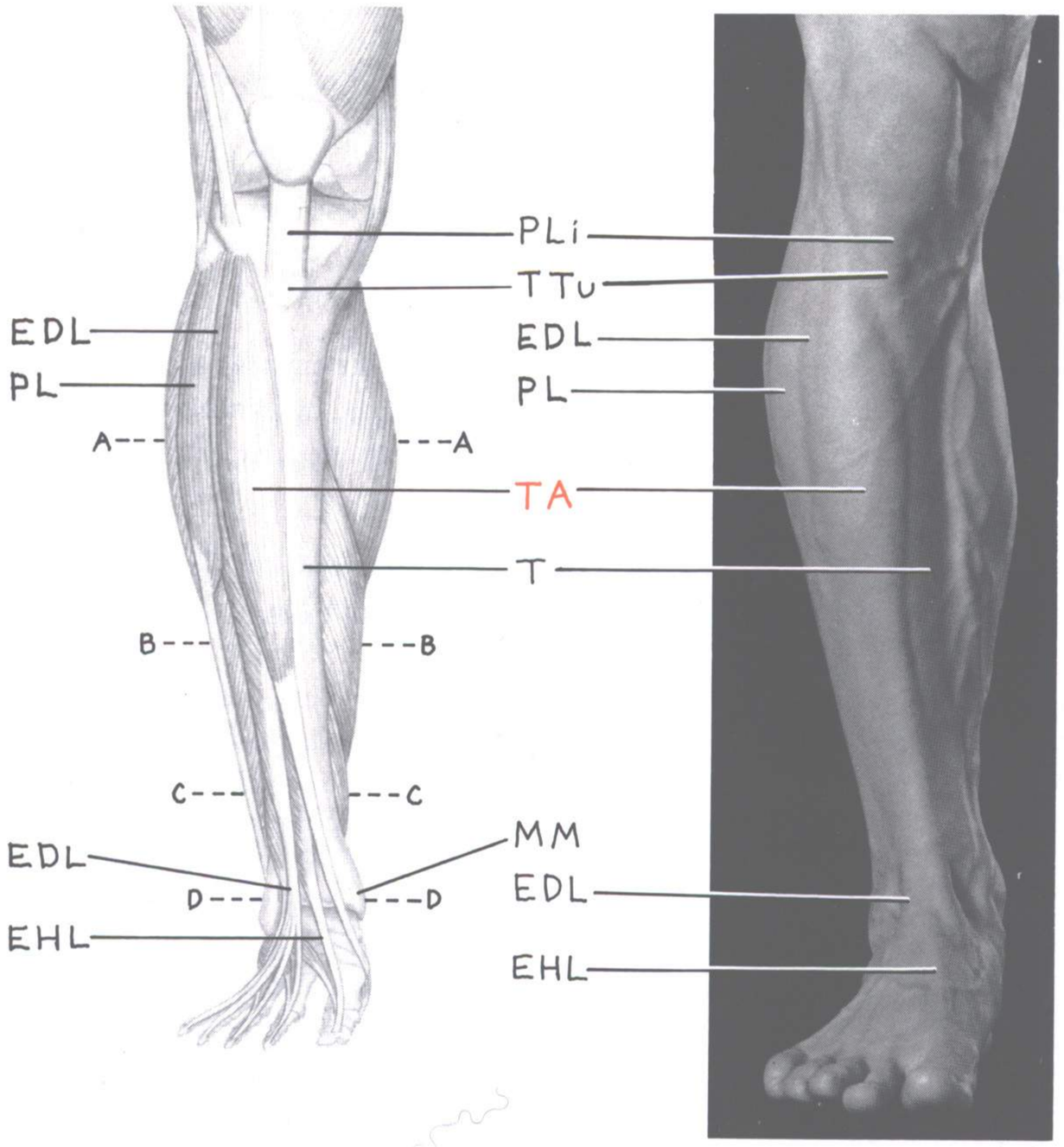


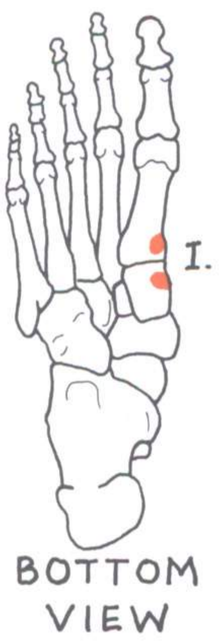
INSIDE VIEW

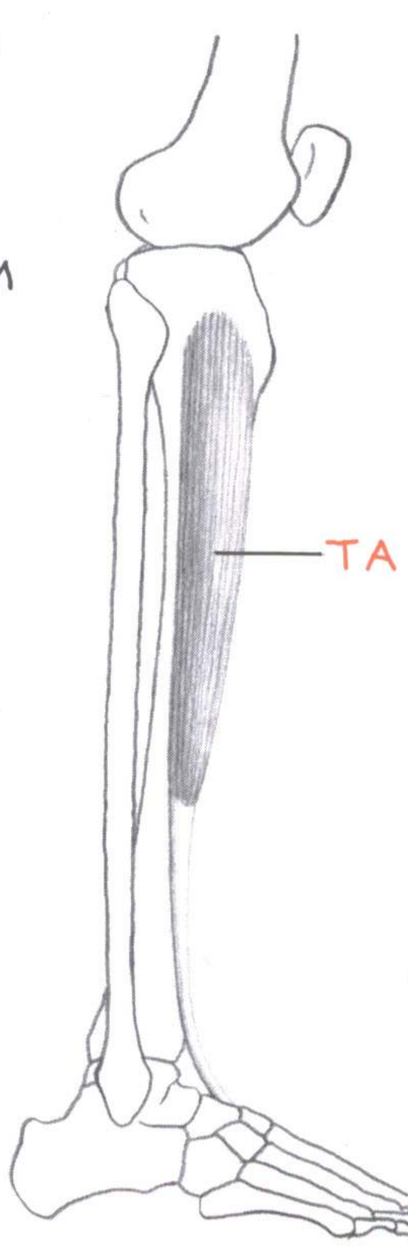


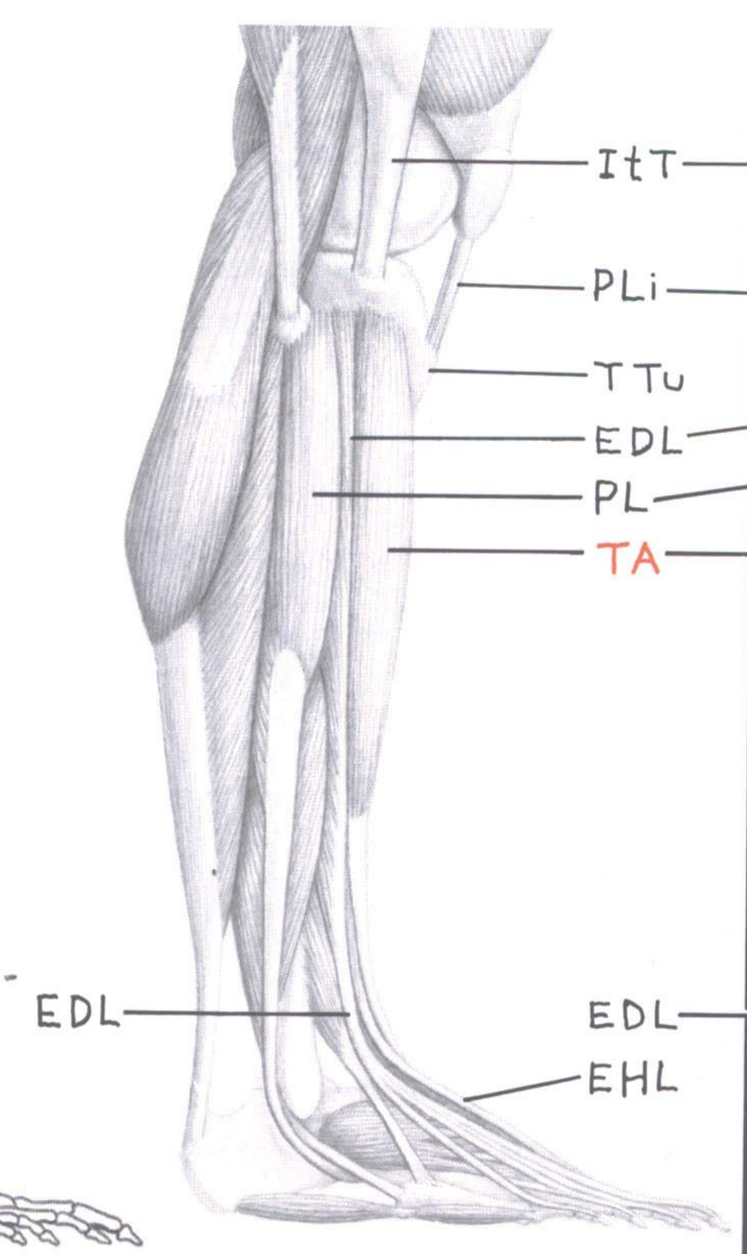
CROSS SECTION



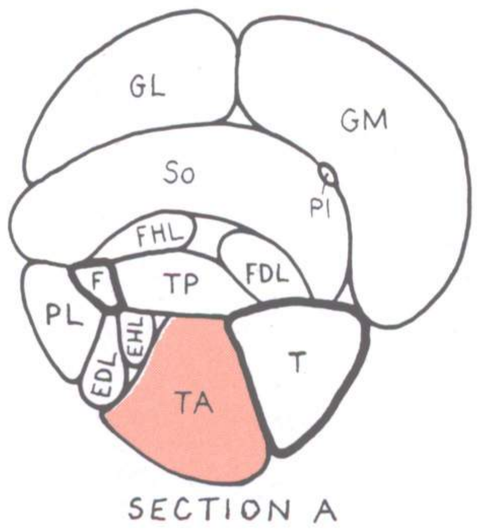




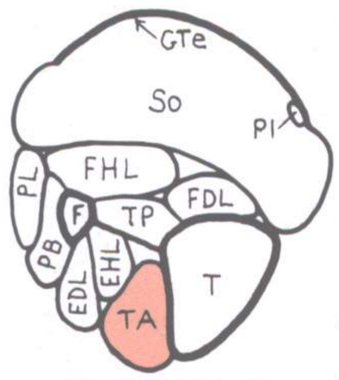




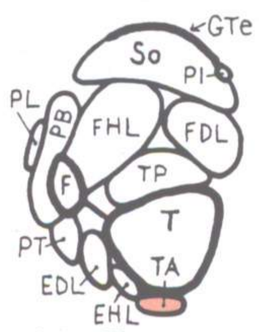
EDL *Extensor digitorum longus* **EHL** *Extensor hallucis longus* **F** *Fibula* **ItT** *Iliotibial tract* **MM** *Medial malleolus* **PL** *Peroneus longus* **PLi** *Patellar ligament* **T** *Tibia* **TA** *Tibialis anterior* **TP** *Tibialis posterior* **TTu** *Tibial tuberosity*



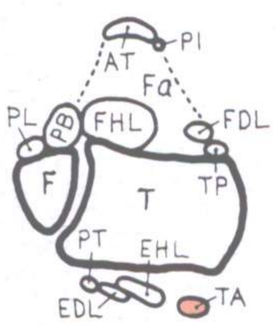
SECTION A



SECTION B



SECTION C



SECTION D

Tibialis Anterior

ORIGIN Lateral condyle of the tibia, lateral surface of the upper half of the shaft of the tibia, adjacent interosseous membrane, and the intermuscular septum between this muscle and the extensor digitorum longus.

INSERTION The bottom of the medial arch of the foot, midway from the front to the back of the foot; specifically, into the medial and bottom surfaces of the medial cuneiform bone and into the base of the first metatarsal bone.

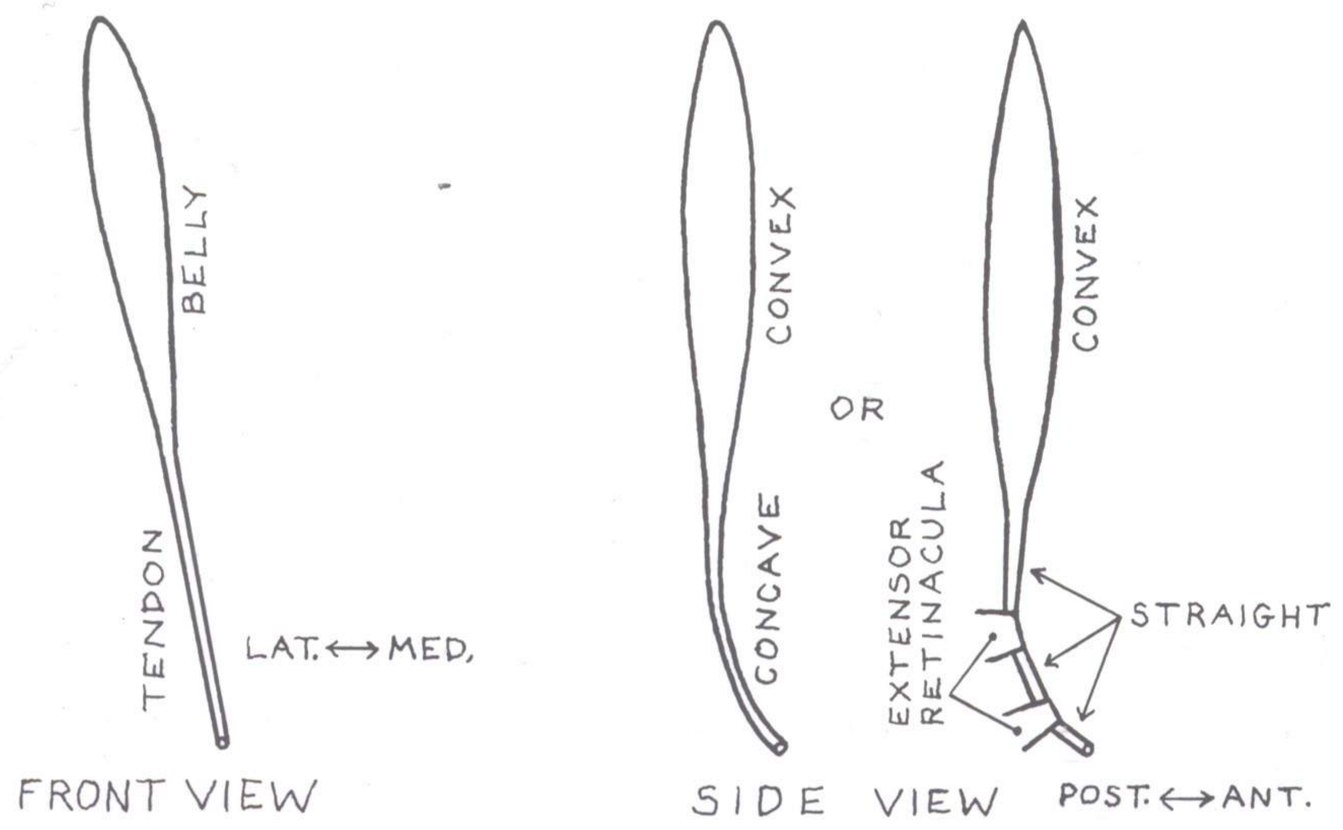
ACTION Dorsiflexes and inverts the foot. During walking, it controls the descent of the foot after the heel strikes the ground.

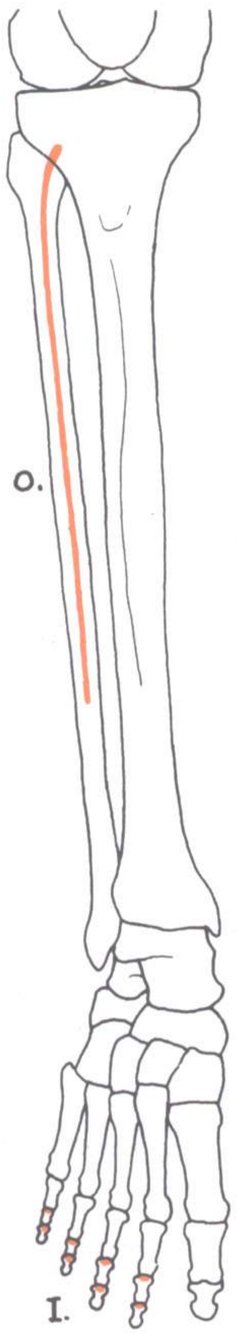
STRUCTURE Thick and fleshy above, the tibialis anterior tapers into its long, prominent tendon two-thirds of the way down the lower leg. The muscle belly is the first form lateral to the tibial tuberosity and anterior edge (the shin) of the tibia. The sharp edge of the shin is *not* covered by this muscle belly. In side view, the muscle belly bulges forward, anterior to the shin, to form the front profile of the top half of the lower leg. It runs down the outside of the shaft of the tibia. Its tendon then crosses diagonally (medially) in front of the ankle joint toward its insertion into the medial arch of the foot. The tibialis anterior therefore subtly spirals down the lower leg, passing from the outside of the knee to the inside of the foot.

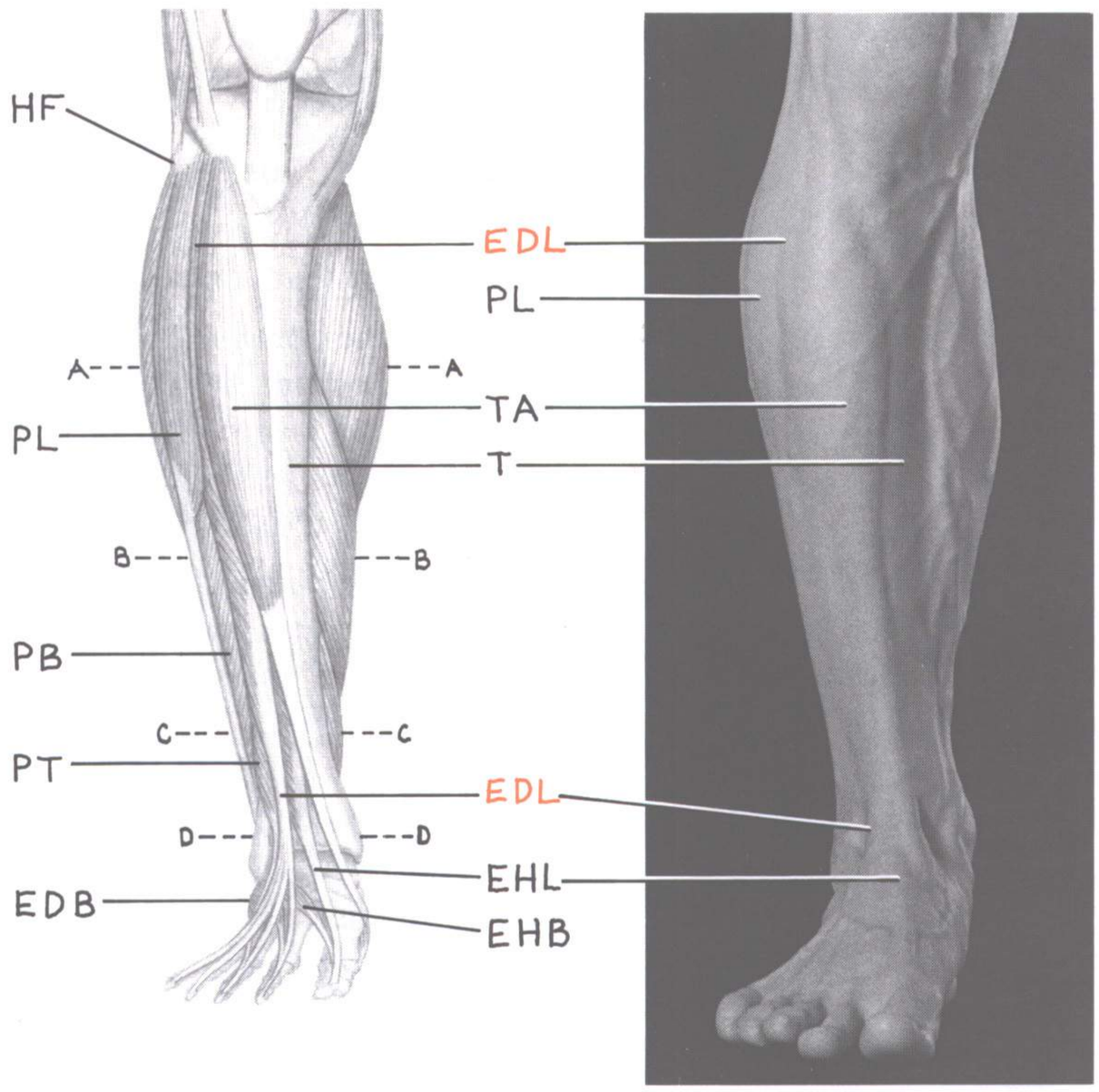
The lateral fibers of the upper portion of the belly thin out and partially cover the upper end of the extensor digitorum longus, obscuring the separation between the muscles and creating one wide form (see cross section). The extreme upper ends of these two muscles can at times be seen separately during strong dorsiflexion and eversion of the foot (as they bulge). During full plantar flexion of the foot, the very top ends of these muscles form a depression just below the lateral condyle of the tibia (because they have been stretched out), while the superior end of the peroneus longus bulges (because it has been shortened, thus becoming thicker).

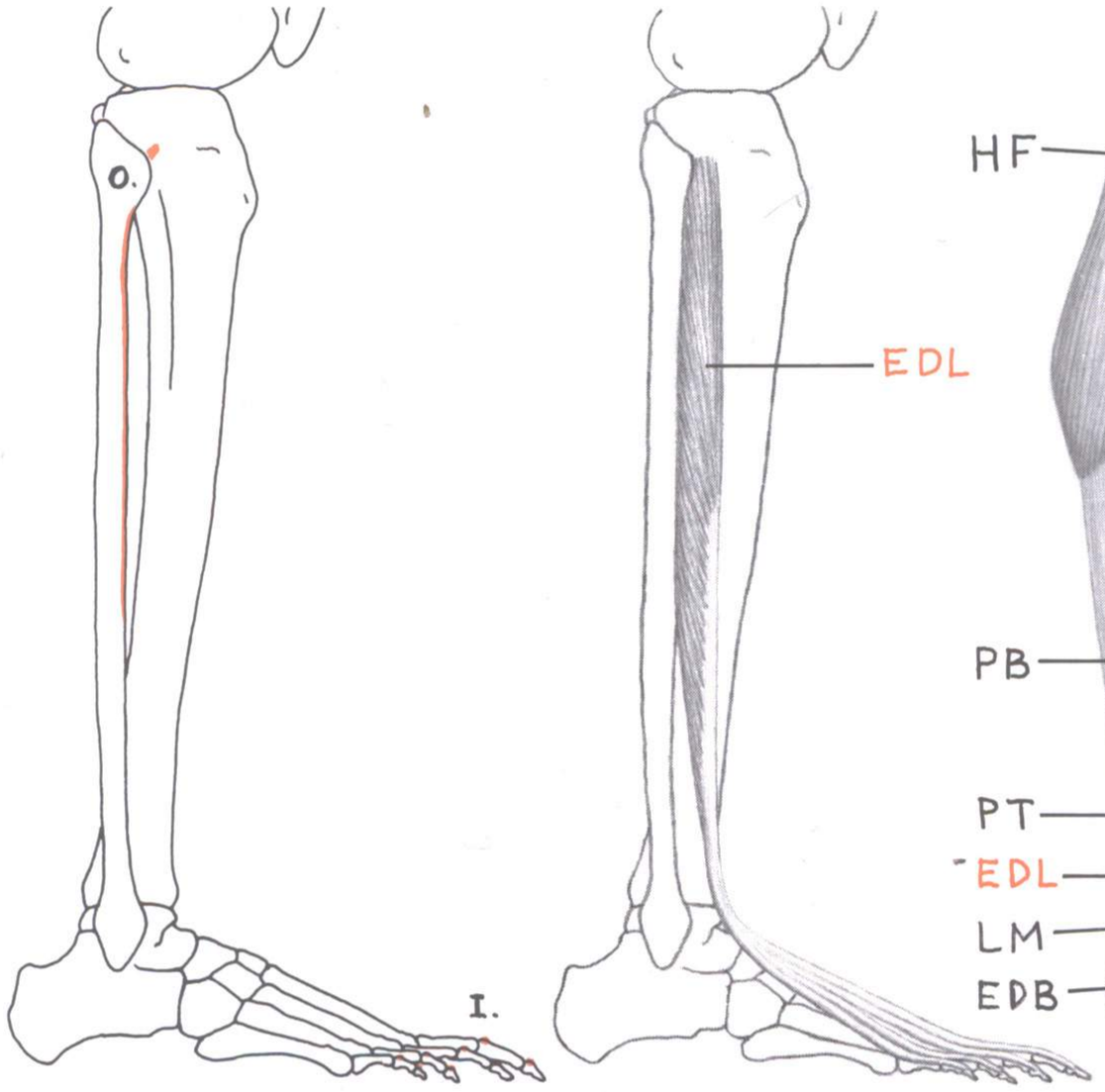
The muscle fibers of the lower end of the tibialis anterior belly continue inserting for a considerable distance onto the deep aspect of its tendon. This produces the elongated taper at the inferior end of the belly. The tendon is wide and flattened where it begins at the lower end of the belly; it gradually rounds off and becomes quite prominent as it descends. On the front of the ankle, the tendon is located medial to the midline. It widens again just before it inserts. At the ankle joint, it is held in place by the inferior extensor retinaculum, which may occasionally be seen stretched between this tendon and the medial malleolus of the tibia when the foot is inverted.

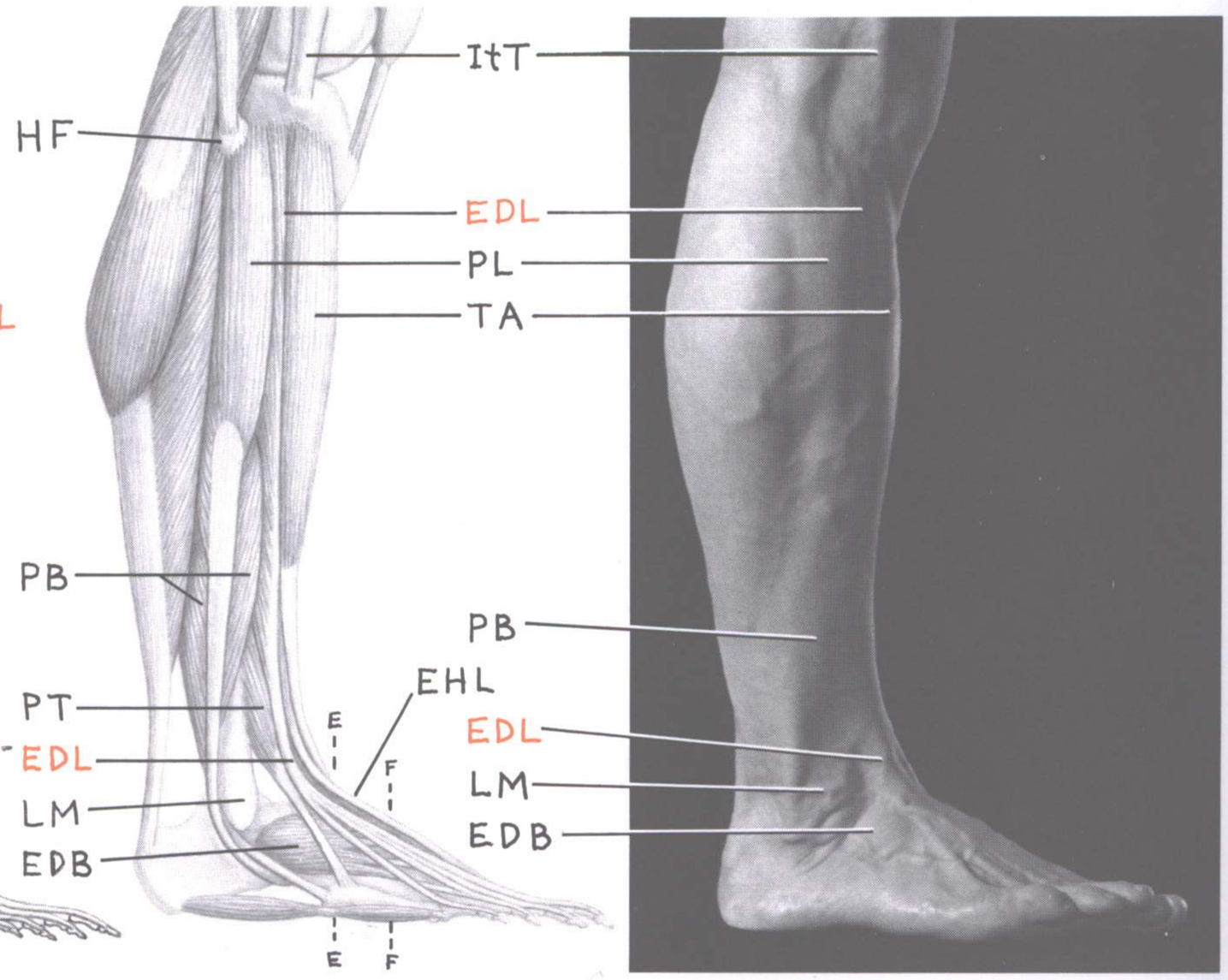
With the foot and big toe flat on the floor, the tendon of the tibialis anterior is the most anterior tendon at the front of the ankle. It spans the gap between the lower end of the tibia and the foot bones (over the ankle joint). The entire tendon can occasionally form a concave curve along the front profile of the lower half of the lower leg (seen in side view). This concavity is the inferior continuation of the convex profile of the belly above. Careful examination of the lower half of the lower leg will show that the front profile is often made up of a series of straight lines. This is caused by the constriction of the tendon at several points by bands of the extensor retinacula, separating the tendon into short, straight portions.



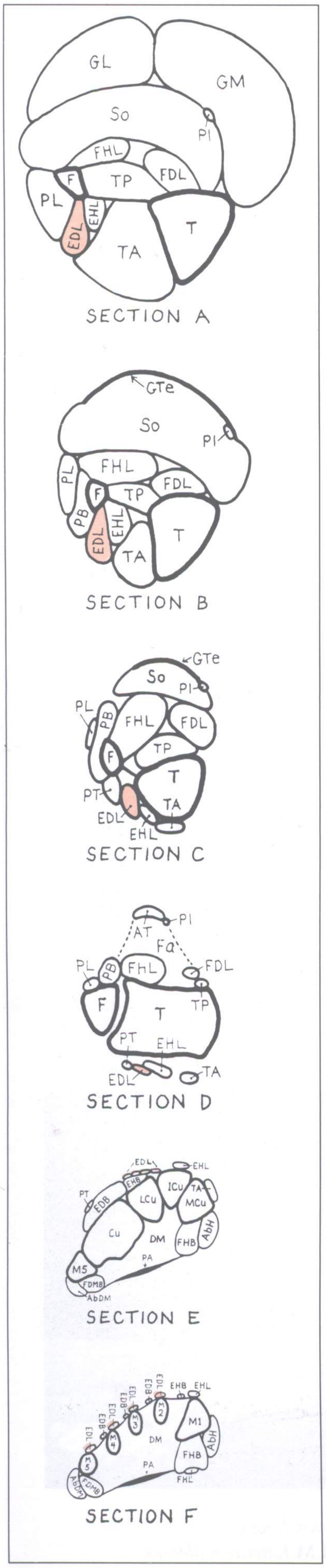








EDB *Extensor digitorum brevis* **EDL** *Extensor digitorum longus* **EHB** *Extensor hallucis brevis*
EHL *Extensor hallucis longus* **F** *Fibula* **HF** *Head of fibula* **ICu** *Intermediate cuneiform*
ItT *Iliotibial tract* **LCu** *Lateral cuneiform* **LM** *Lateral malleolus* **M** *Metatarsal*
PB *Peroneus brevis* **PL** *Peroneus longus* **PT** *Peroneus tertius* **T** *Tibia* **TA** *Tibialis anterior*



Extensor Digitorum Longus

ORIGIN The outer side of the lateral condyle of the tibia; the upper three-fourths of the anterior surface (or front edge) of the fibula; the adjacent interosseous membrane; and the intermuscular septa between this muscle and the tibialis anterior on one side and the peroneal muscles on the other side.

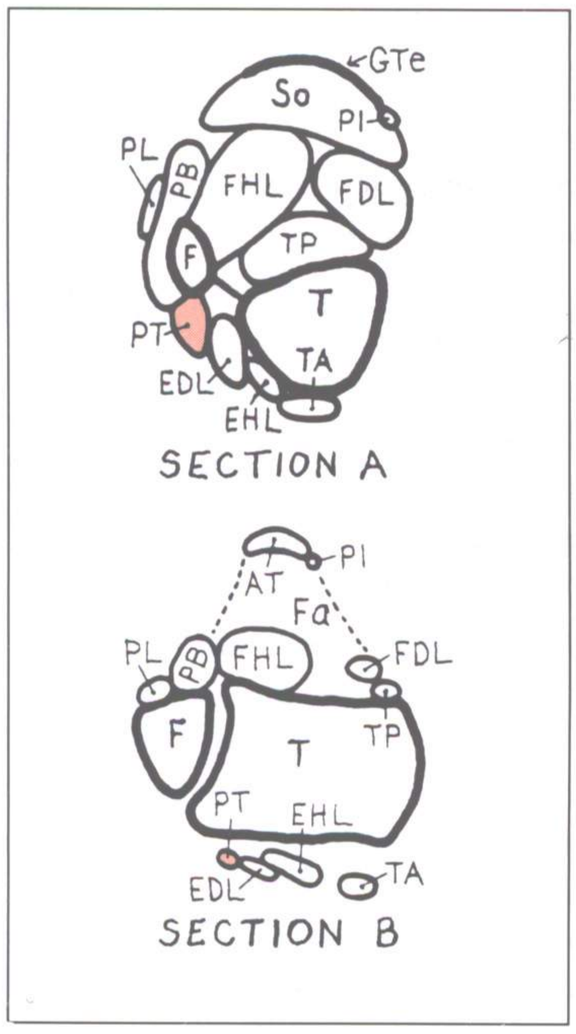
INSERTION Top surfaces of the middle and distal phalanges of toes two through five (to the lateral four toes; the extensor digitorum longus does *not* go to the big toe).

ACTION Extends toes two through five; dorsiflexes the foot at the ankle joint (raises foot) and weakly everts it (faces sole outward). The toes separate when they are extended (they come together when they are flexed).

STRUCTURE The long, thin extensor digitorum longus actually consists of four combined bellies and their tendons (one to each of the lateral four toes). The upper portion of the muscle is usually not seen, as it is partly covered by the tibialis anterior, which usually blends with it (dense fascia covering the bellies also obscures their separation). The extensor digitorum longus is unipennate—it develops its tendons along the anterior edge of its belly, beginning just above the midpoint of the lower leg. The belly itself ends approximately three-fourths of the way down the lower leg. Its elongated form is continued inferiorly by the belly of the peroneus tertius, which although a separate muscle, is somewhat attached.

On the lower portion of the lower leg, the muscle belly narrows, and the four tendons remain close together. They appear to be a single combined tendon, or wide "cable," as they pass down the front of the ankle, lateral to the midline. This cable becomes most prominent when the foot is everted. When the combined tendon reaches the dorsum of the foot, its four tendons separate and diverge; they may clearly be seen on the top of the foot when the toes are extended. Distally, the tendons disappear from sight on top of the middle of the proximal phalanges, as they widen into a tendinous expansion, the **digital extensor hood,** which continues onward to the insertion. The visible tendon of the little toe is directed toward the head of its metatarsal, not toward the tip of the toe. The others are directed straight toward the ends of the toes.

On occasion, the very superior tip of the fleshy belly of the extensor digitorum longus, at its origin on the lateral condyle of the tibia (between the tibialis anterior and peroneus longus), may be seen. It will appear as a short, raised, linear form when the muscle is contracted to extend the toes (the entire muscle gets shorter and thicker). If the toes are flexed, the extensor digitorum longus will become stretched, and this same area will show up as a narrow, vertical depression.



Peroneus Tertius
(Fibularis Tertius)

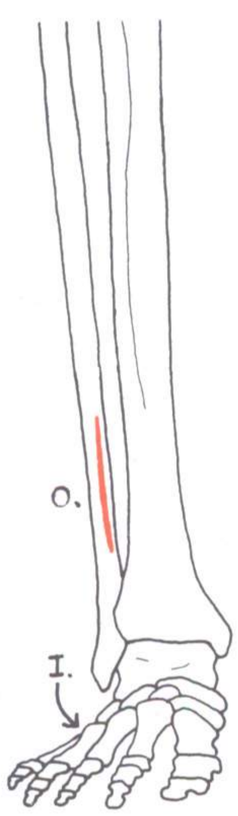
ORIGIN Lower third of the anterior surface of the shaft of the fibula (not including the lateral malleolus), the adjacent interosseous membrane, and the intermuscular septum between it and the peroneus brevis.

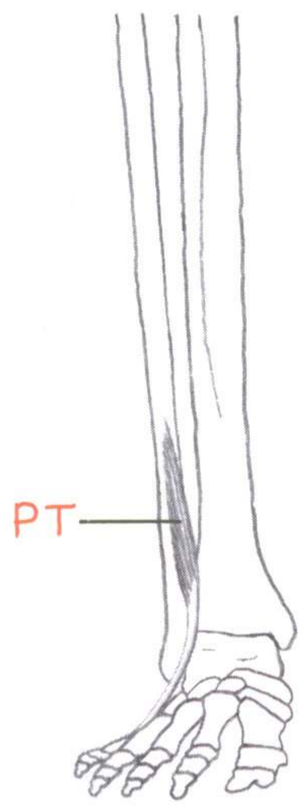
INSERTION Variably into the dorsal surface of the fifth metatarsal bone (of the little toe) at its base or slightly forward of it.

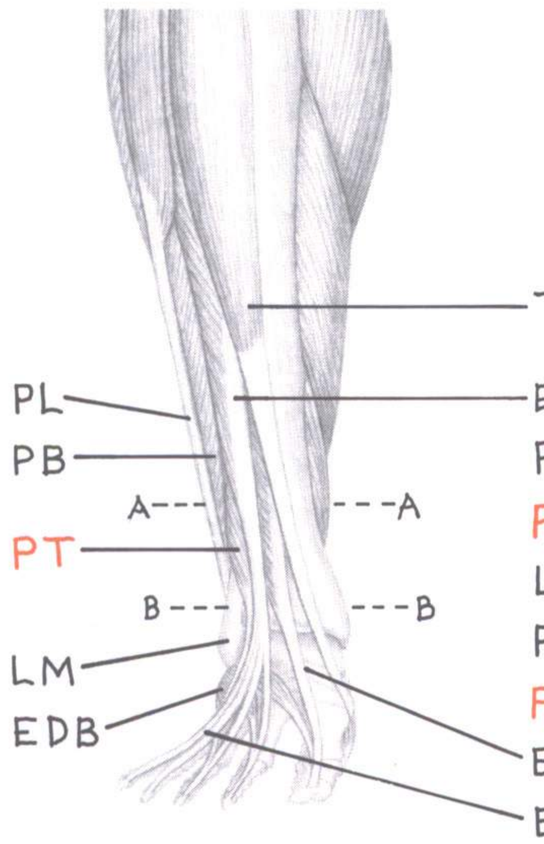
ACTION Dorsiflexes (lifts) and everts the foot.

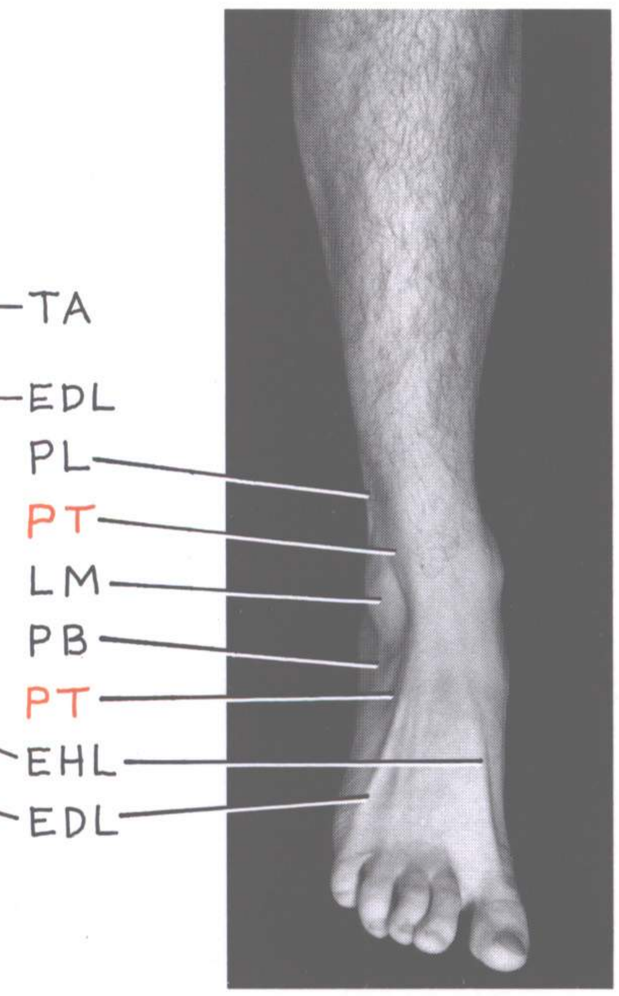
STRUCTURE The belly of the peroneus tertius can be visualized as a downward continuation of the form of the belly of the extensor digitorum longus. Its fleshy belly descends as low as the lateral malleolus. Its tendon begins on the front edge of its belly and passes downward alongside the tendons of the extensor digitorum longus. These tendons all pass down the front of the ankle together (lateral to the midline) and then separate on the dorsum of the foot. The flattened tendon of the peroneus tertius then passes over the belly of the extensor digitorum brevis and widens just before it finally inserts. This subtle tendon is seen only occasionally, either as a raised tendon or as a furrow on the belly of the extensor digitorum brevis.

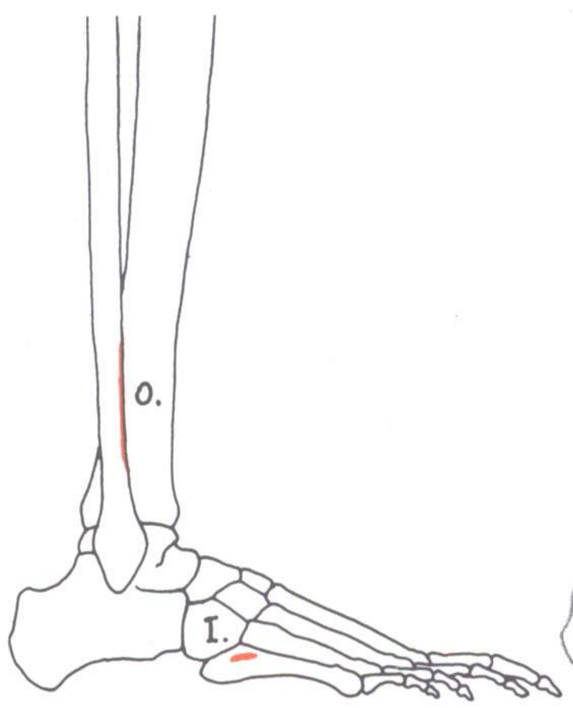
Superiorly, the peroneus tertius lies against the peroneus brevis, but the forms of these two muscles usually blend together. The peroneus tertius then passes downward and slightly forward, separating from the peroneus brevis and exposing the lower portion of the shaft of the fibula.

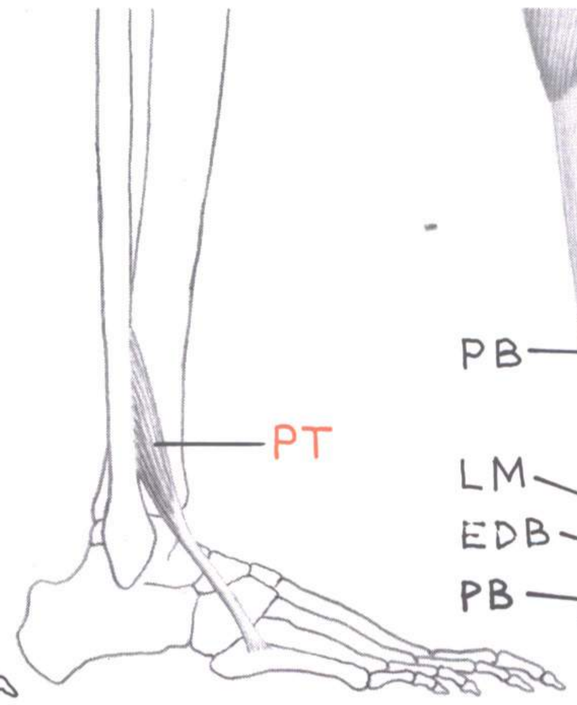


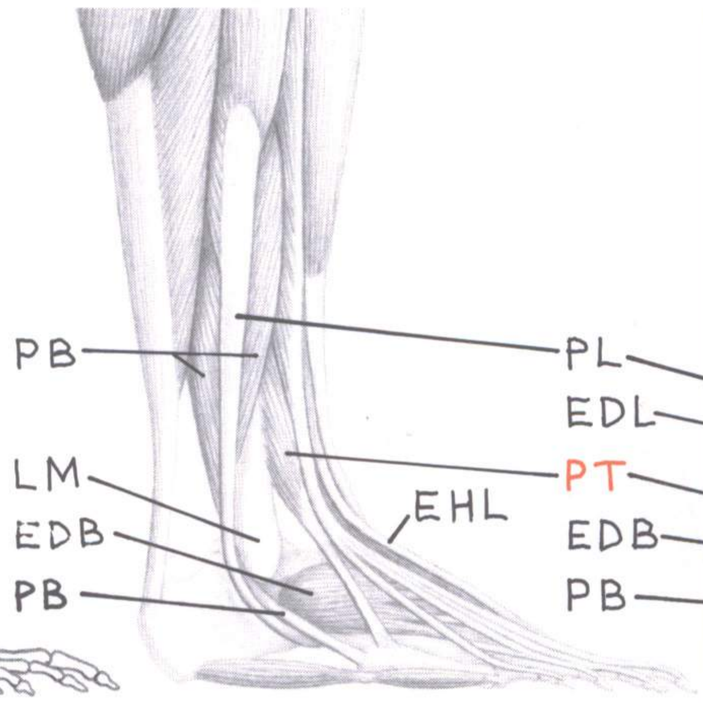


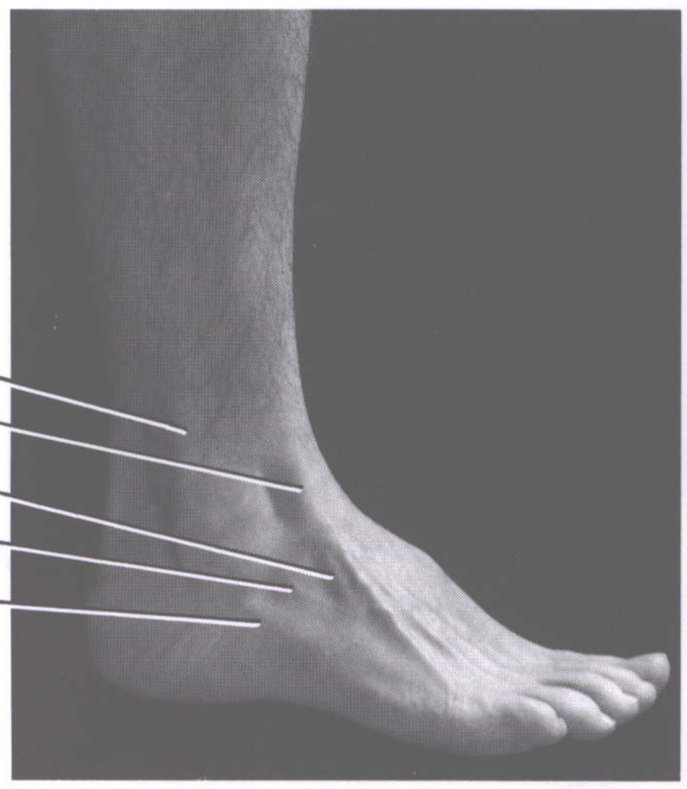




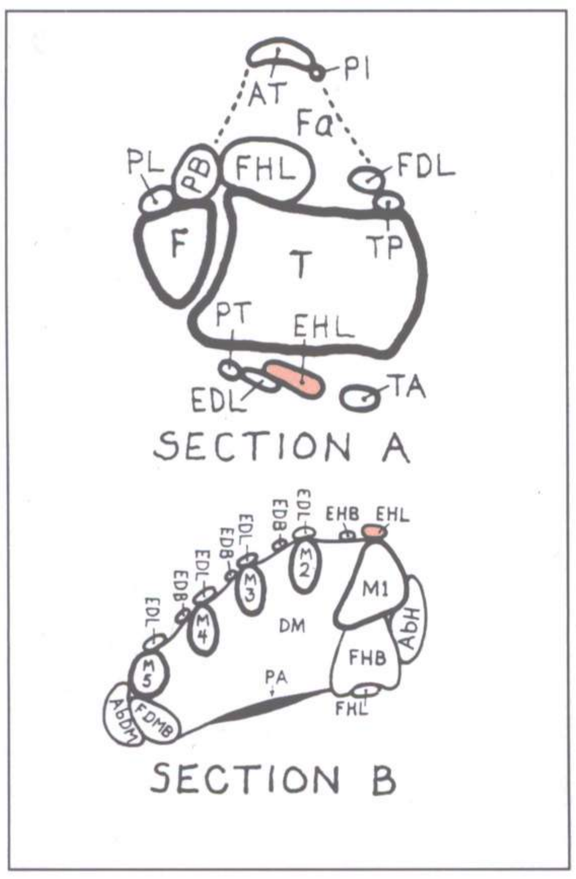








DM *Deep muscle* **EDB** *Extensor digitorum brevis* **EDL** *Extensor digitorum longus*
EHB *Extensor hallucis brevis* **EHL** *Extensor hallucis longus* **F** *Fibula* **LM** *Lateral malleolus*



Extensor Hallucis Longus

ORIGIN Middle half of the medial surface of the fibula (medial to the origin of the extensor digitorum longus) and the adjacent interosseous membrane.

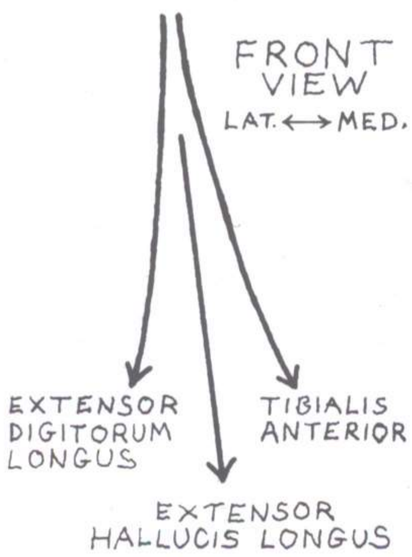
INSERTION The top of the base of the distal phalanx of the big toe.

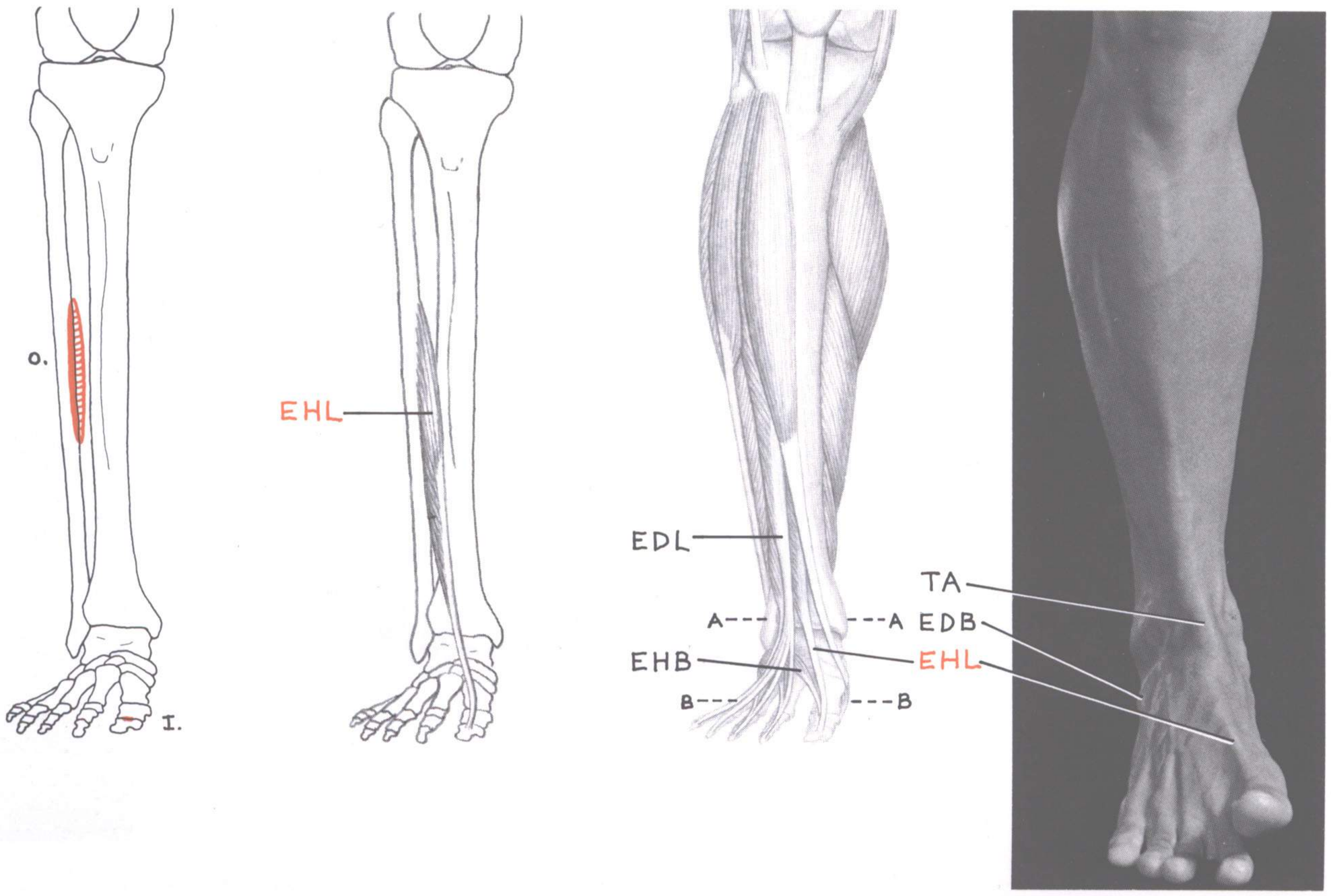
ACTION Extends the big toe; assists in dorsiflexion of the foot.

STRUCTURE The belly of the extensor hallucis longus for the most part lies deep in the lower leg. Its tendon, beginning on the anterior border of its muscle belly, emerges from between the extensor digitorum longus and tibialis anterior roughly two-thirds of the way down the lower leg, but is usually not clearly seen at this point. When the big toe is extended, the tendon becomes visible as it passes down the midline of the front of the ankle and shows up quite prominently as it descends along the upper surface of the foot on top of the metatarsal of the big toe. It finally disappears just before reaching the interphalangeal joint of the big toe.

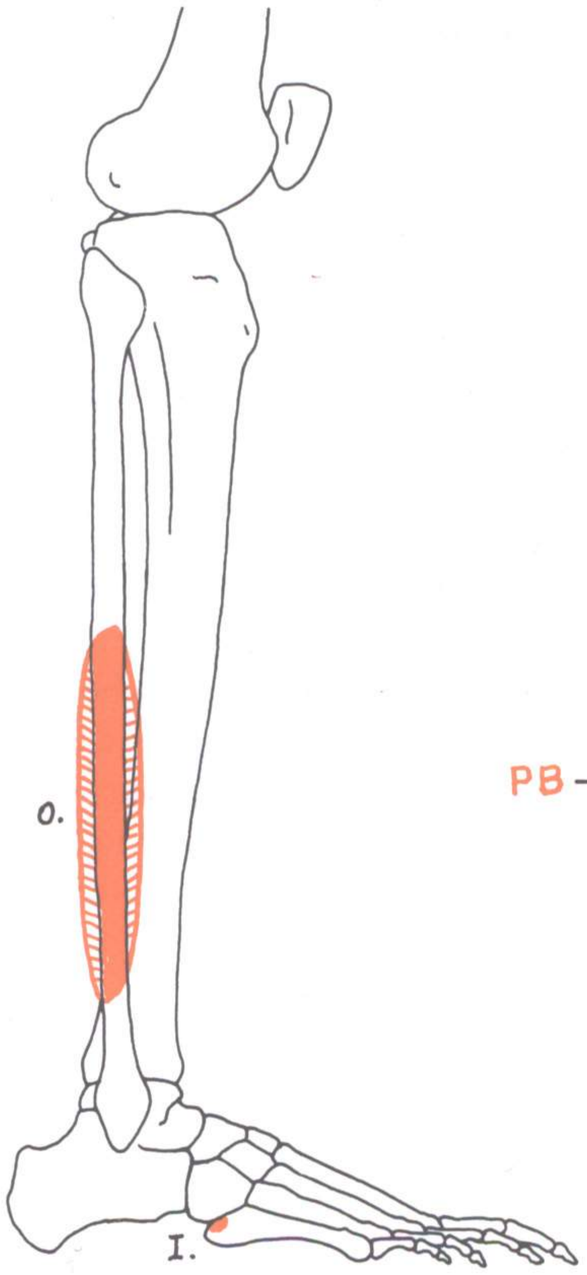
In the side profile view of the ankle, with the foot standing flat on the floor, the most anterior tendon is that of the tibialis anterior. When the big toe is raised (extended), the tendon of the extensor hallucis longus becomes the most anterior tendon.

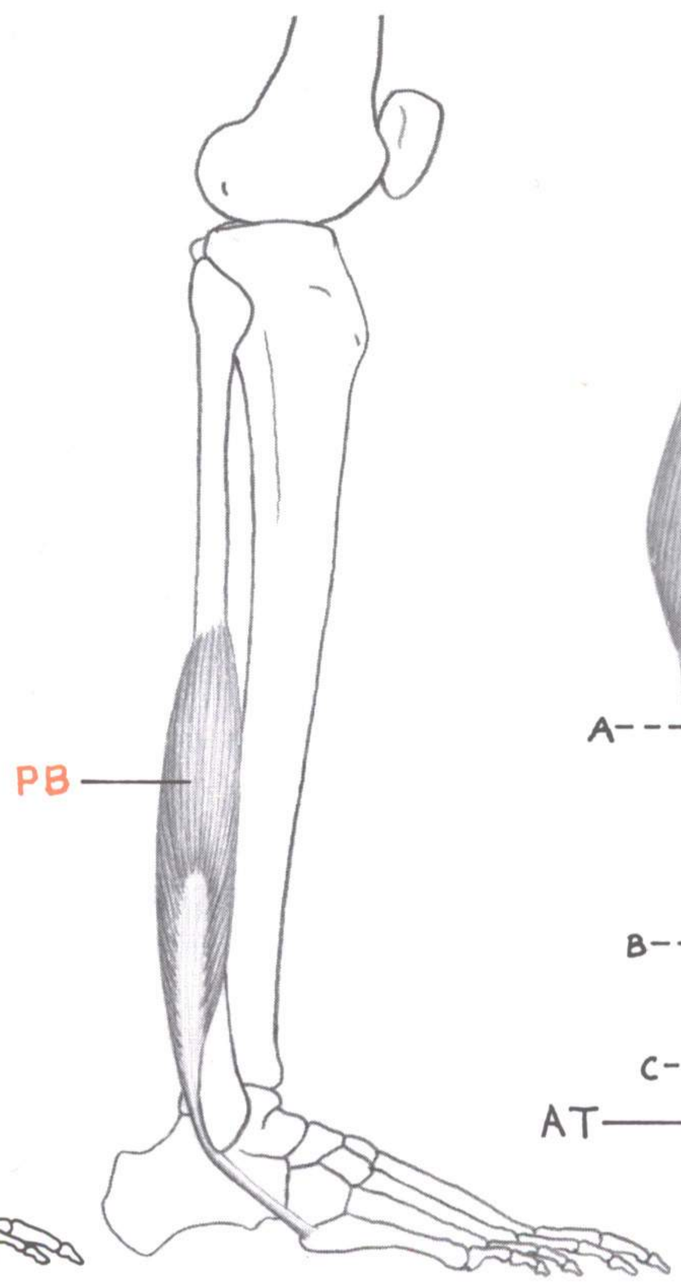
With the foot dorsiflexed and the big toe alternately flexing and extending, the lower end of the belly of the extensor hallucis longus can be seen sliding up and down at the point where it emerges on the front of the lower leg—it appears as a depression when the toe is extended (the belly shortens and its lower end slides up and disappears) and as a small, elongated bulge when the toe is flexed (the tendon pulls the belly down, exposing it).

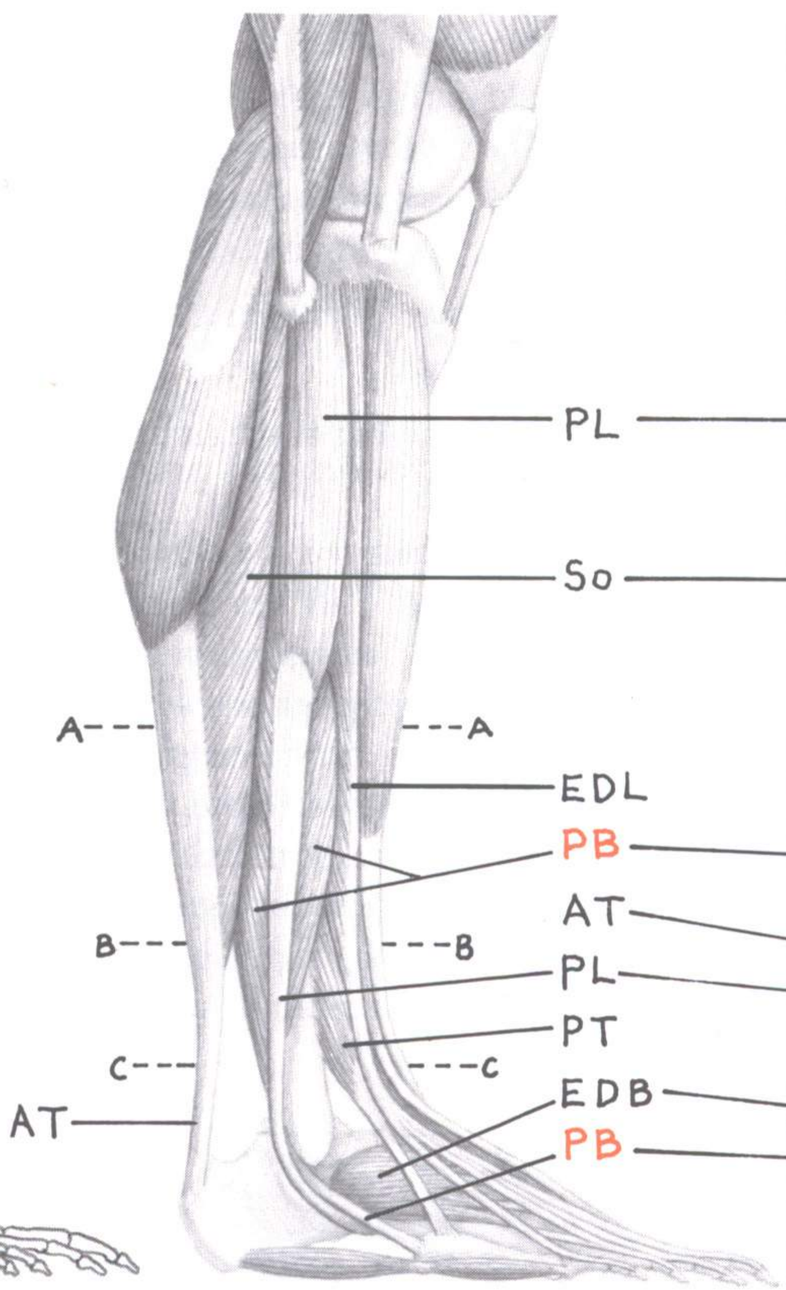


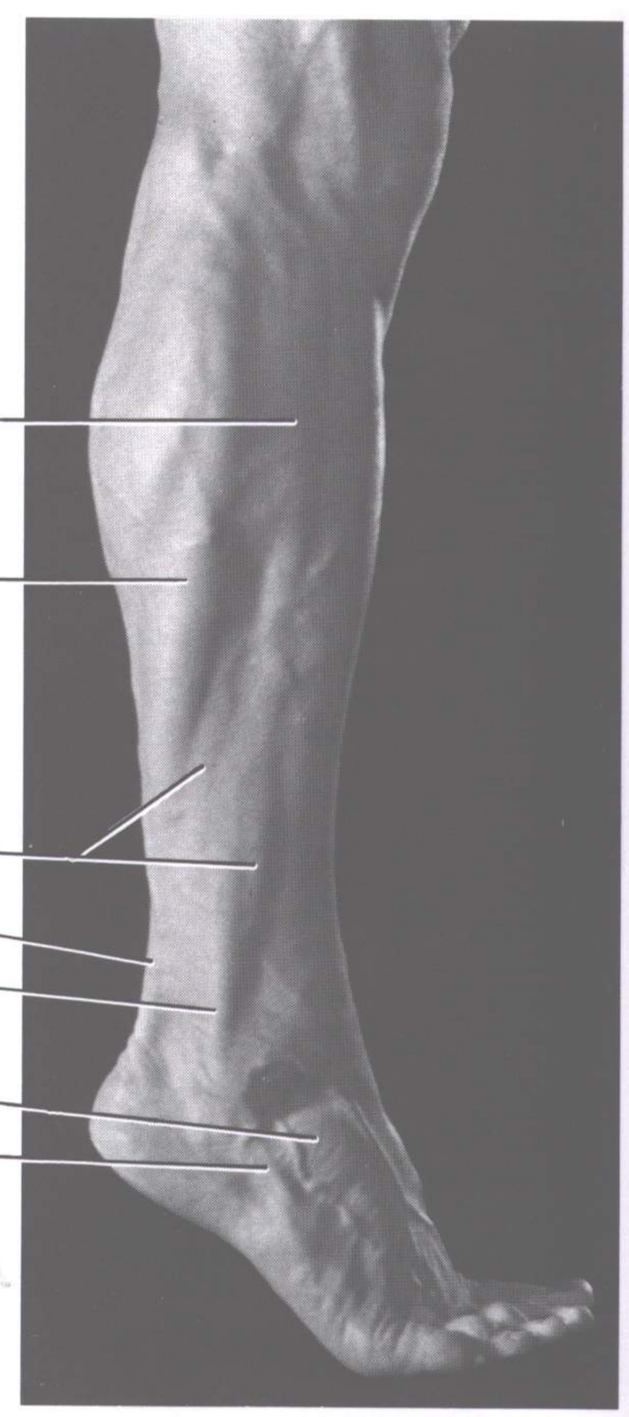


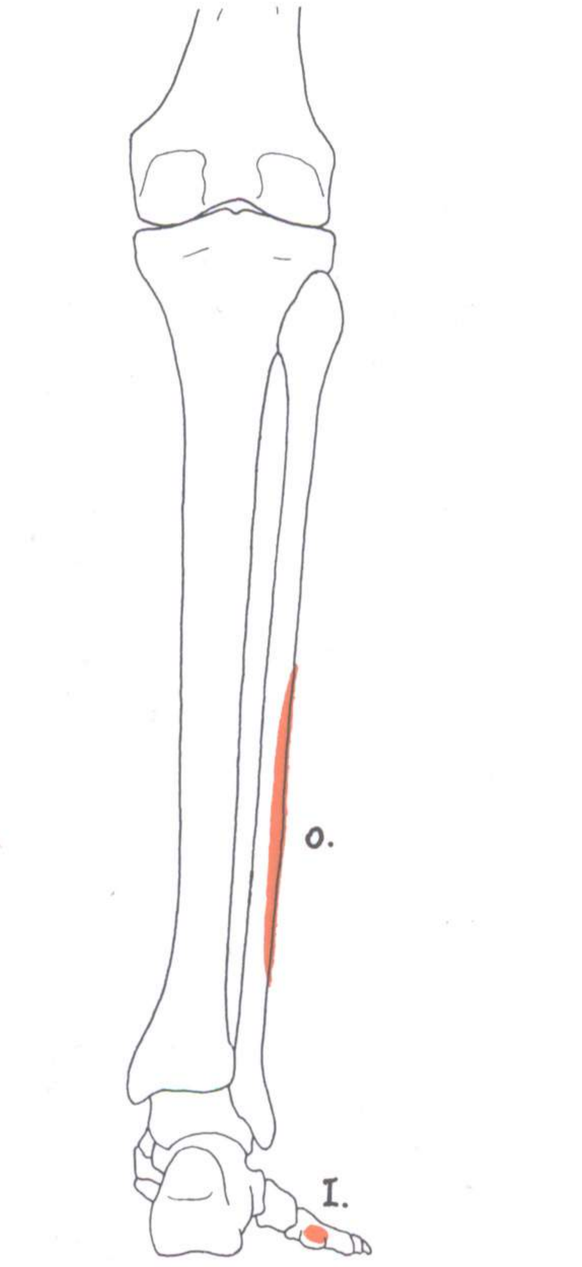
M *Metatarsal* **PB** *Peroneus brevis* **PL** *Peroneus longus* **PT** *Peroneus tertius* **T** *Tibia* **TA** *Tibialis anterior*

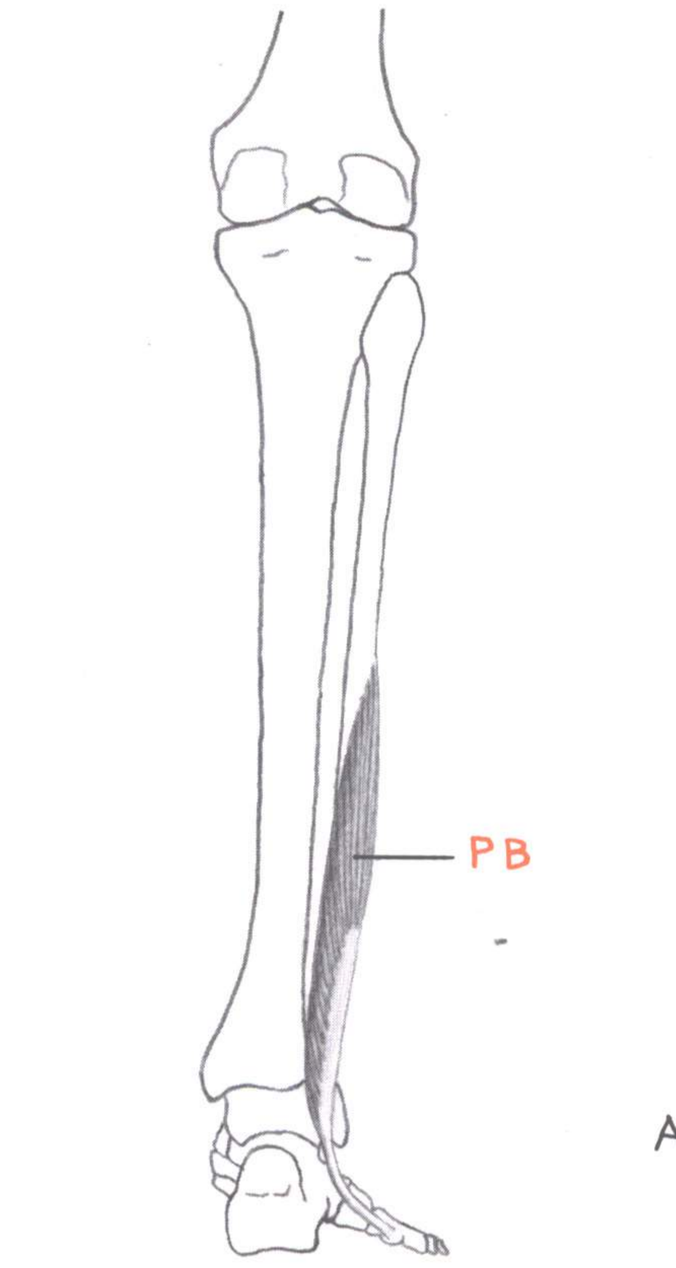


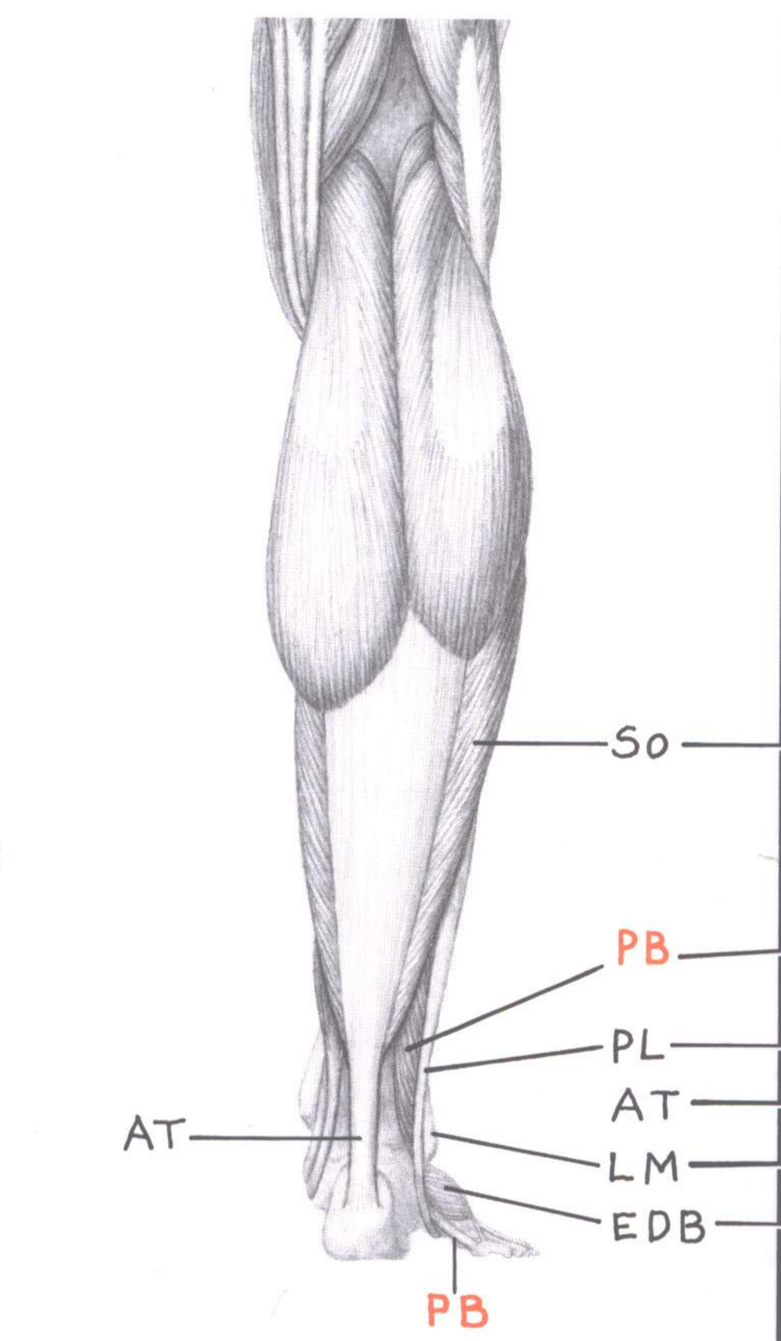


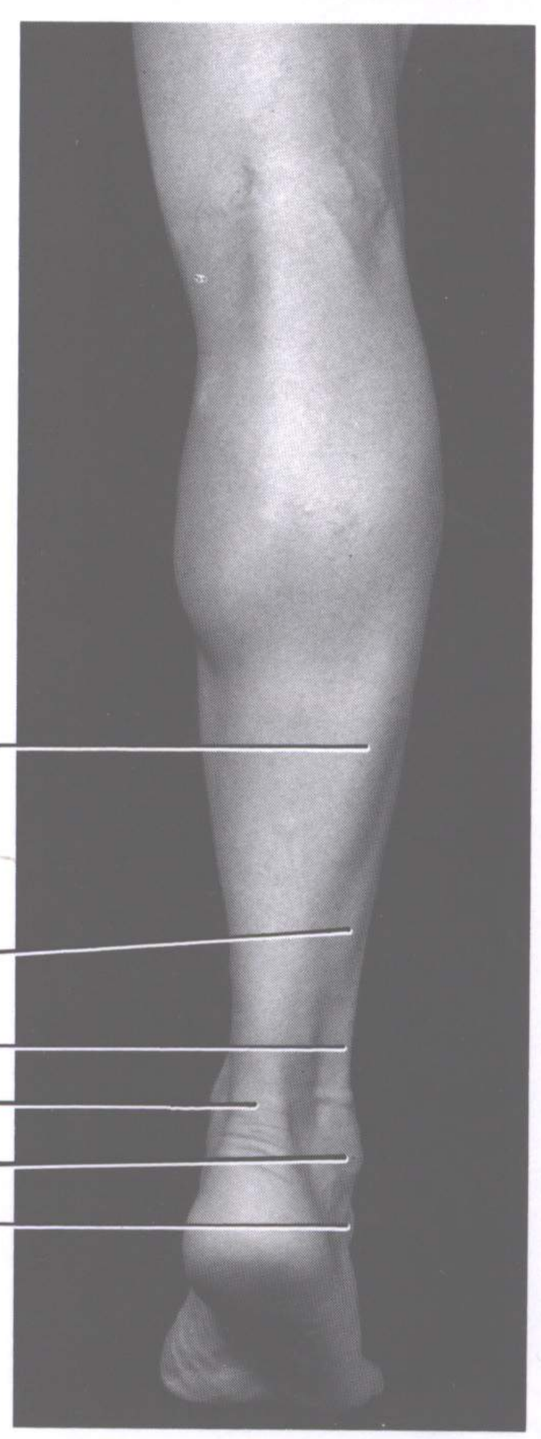




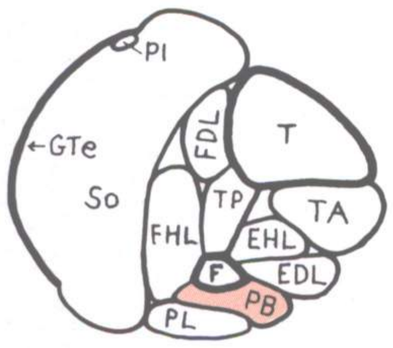




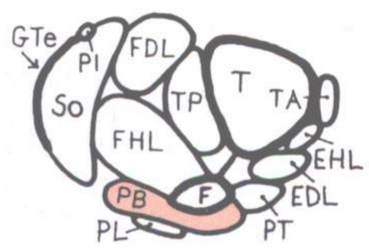




AT *Achilles tendon* **EDB** *Extensor digitorum brevis* **EDL** *Extensor digitorum longus* **F** *Fibula* **Fa** *Fat* **FHL** *Flexor hallucis longus* **LM** *Lateral malleolus* **PB** *Peroneus brevis* **PL** *Peroneus longus* **PT** *Peroneus tertius* **So** *Soleus* **T** *Tibia*



SECTION A



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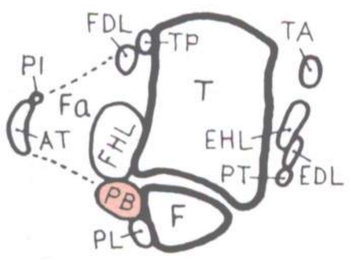


SECTION C

Peroneus Brevis

ORIGIN Lower two-thirds of the lateral surface of the shaft of the fibula (except the very distal end of the shaft) and the intermuscular septa on both the anterior and posterior sides of its belly.

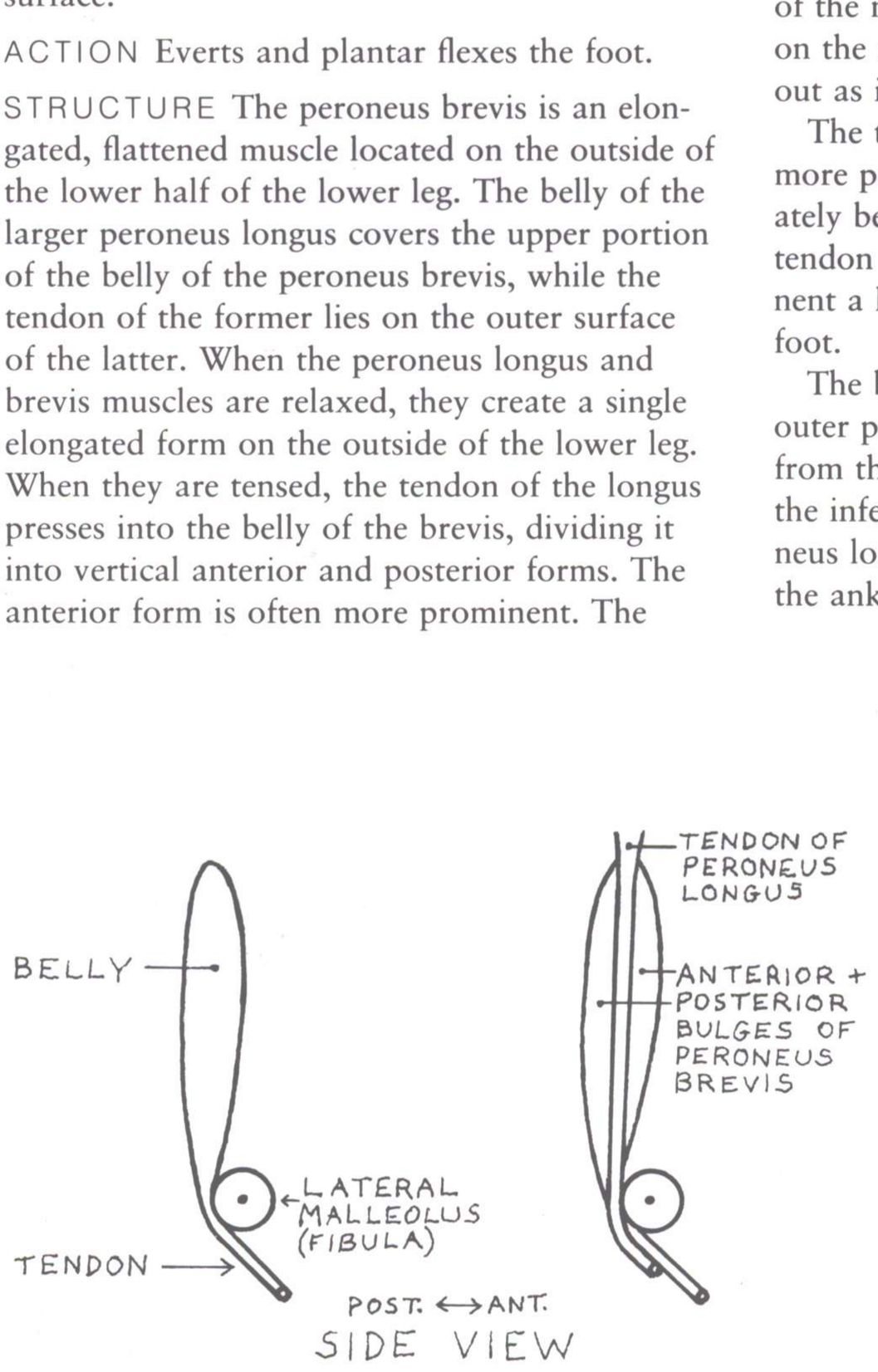
INSERTION Enlarged base of the metatarsal bone of the little (fifth) toe, on its dorsolateral surface.

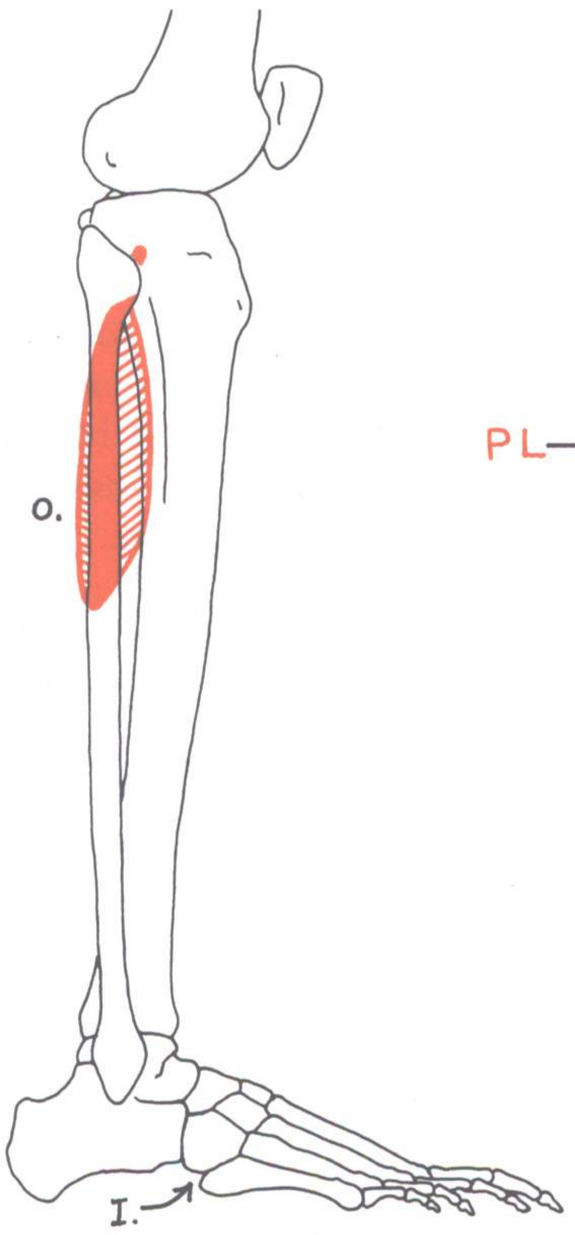
ACTION Everts and plantar flexes the foot.

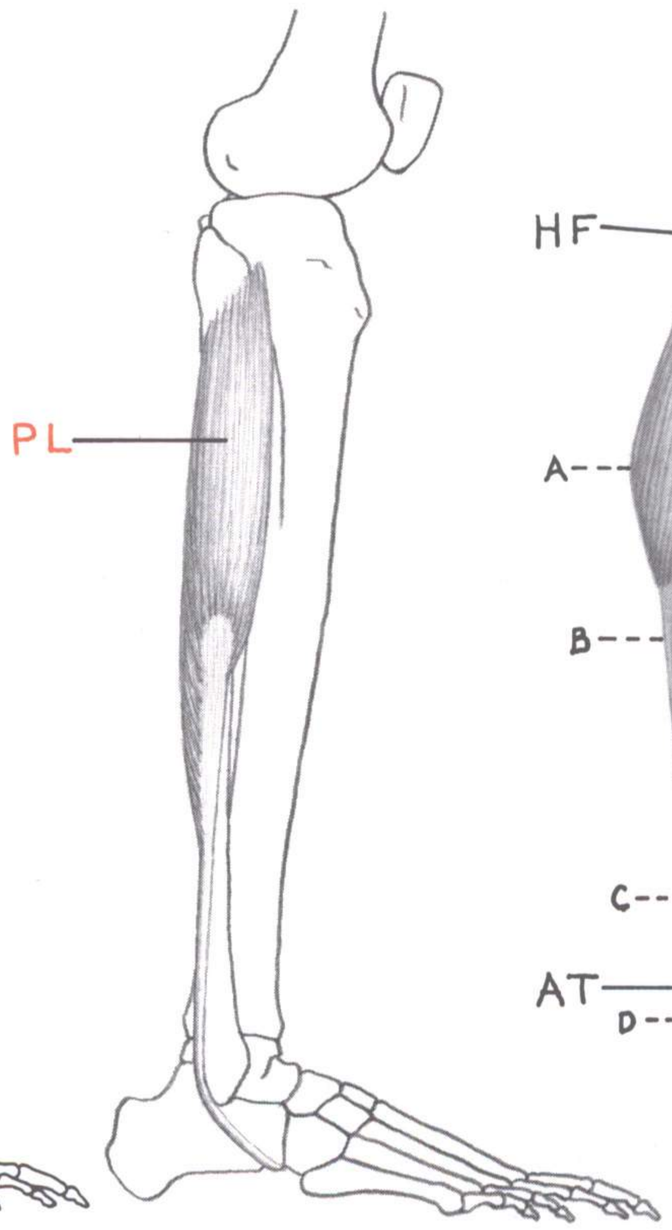
STRUCTURE The peroneus brevis is an elongated, flattened muscle located on the outside of the lower half of the lower leg. The belly of the larger peroneus longus covers the upper portion of the belly of the peroneus brevis, while the tendon of the former lies on the outer surface of the latter. When the peroneus longus and brevis muscles are relaxed, they create a single elongated form on the outside of the lower leg. When they are tensed, the tendon of the longus presses into the belly of the brevis, dividing it into vertical anterior and posterior forms. The anterior form is often more prominent. The posterior form is sometimes joined by those fibers of the peroneus longus that travel down the back edge of its tendon. The fleshy fibers of the peroneus brevis continue all the way down to the bottom of the back of the lateral malleolus. After its tendon passes down the groove on the back of the lateral malleolus, deep to (anterior to) the tendon of the peroneus longus, it sharply turns diagonally forward at the bottom of the malleolus and heads toward its insertion on the middle of the outside of the foot. It fans out as it inserts.

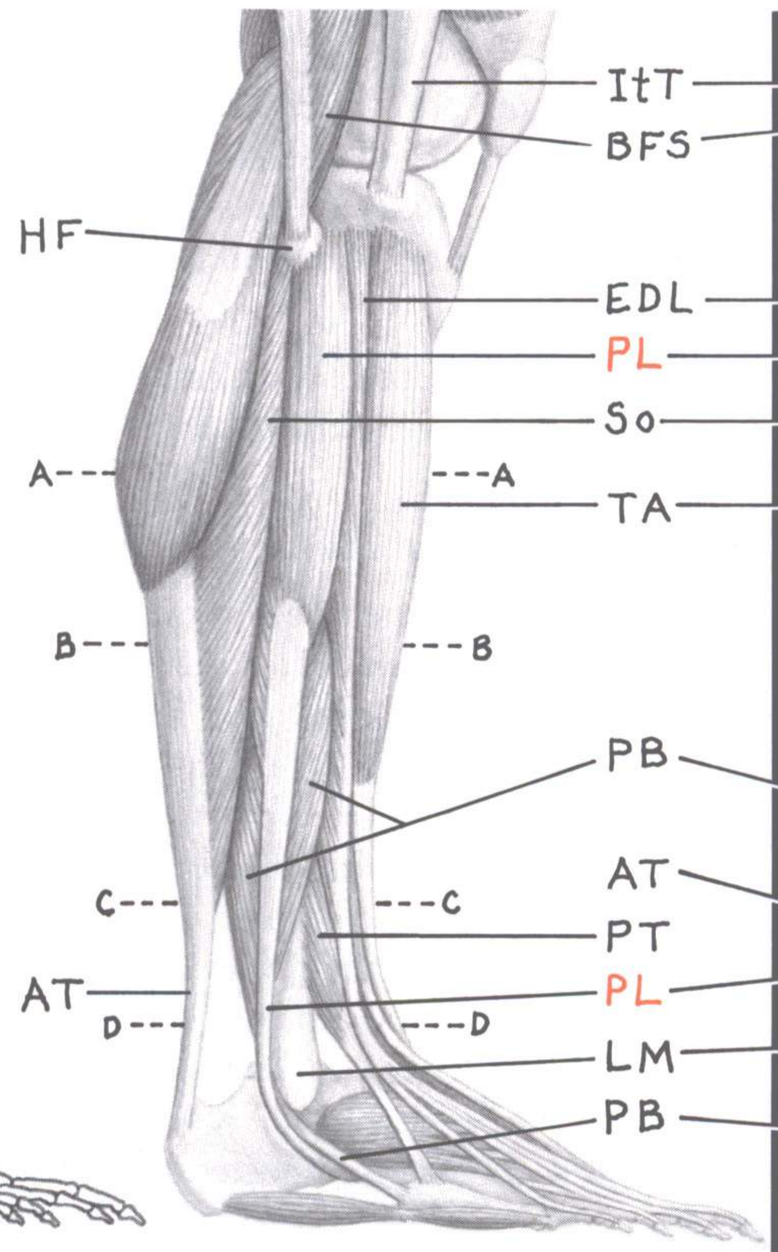
The tendon of the peroneus longus is usually more prominent for a short distance immediately below the lateral malleolus, but then the tendon of the brevis often becomes more prominent a little further along on the outside of the foot.

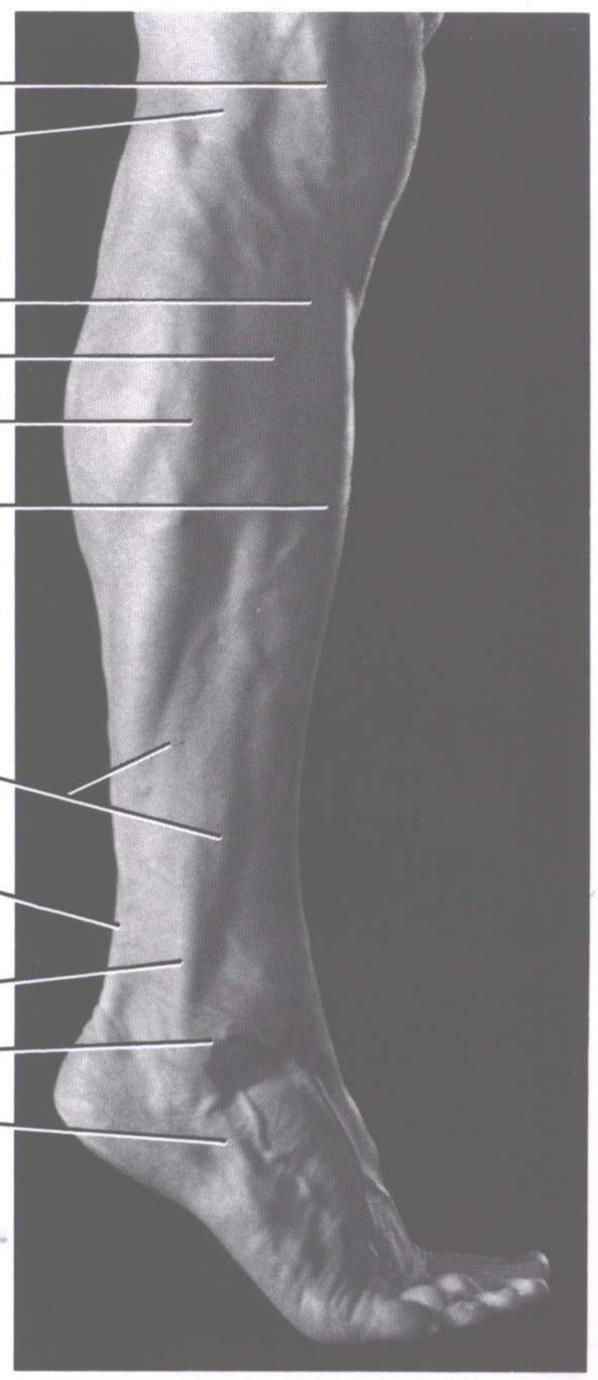
The belly of the peroneus brevis forms the outer profile of the lower half of the lower leg from the front view, up to the point at which the inferior portion of the tendon of the peroneus longus becomes raised and visible (above the ankle).

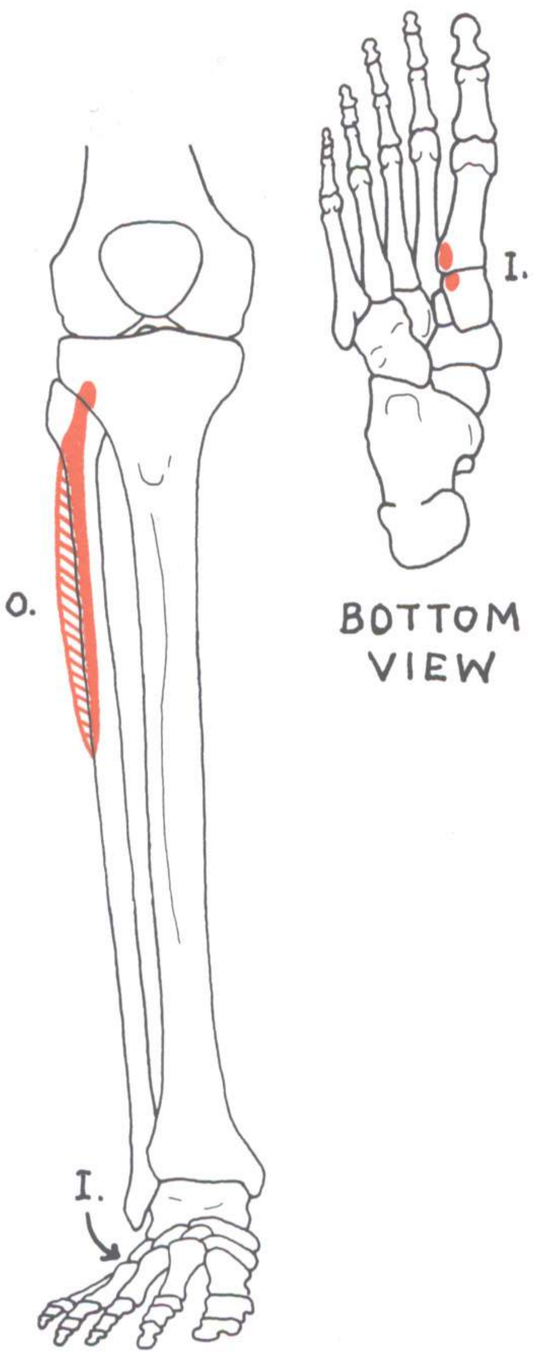


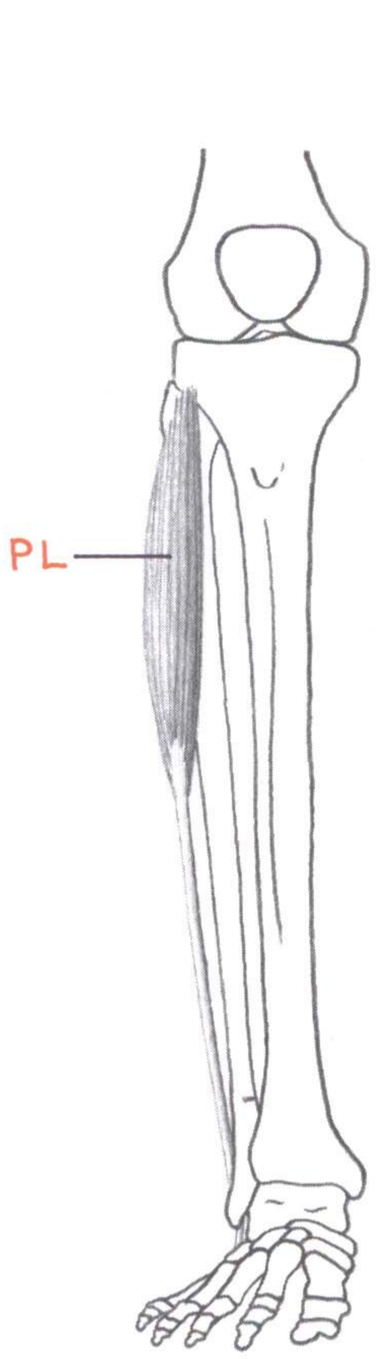


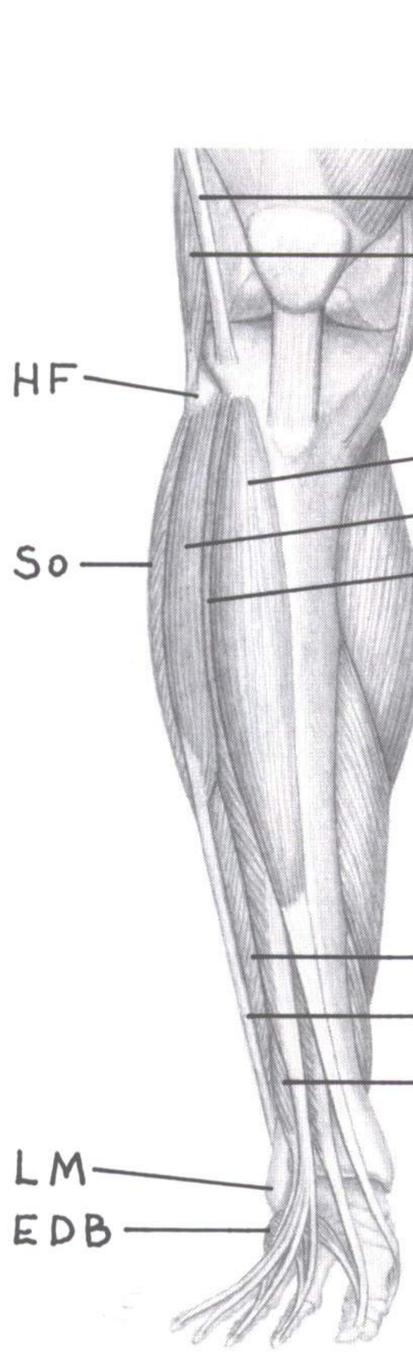


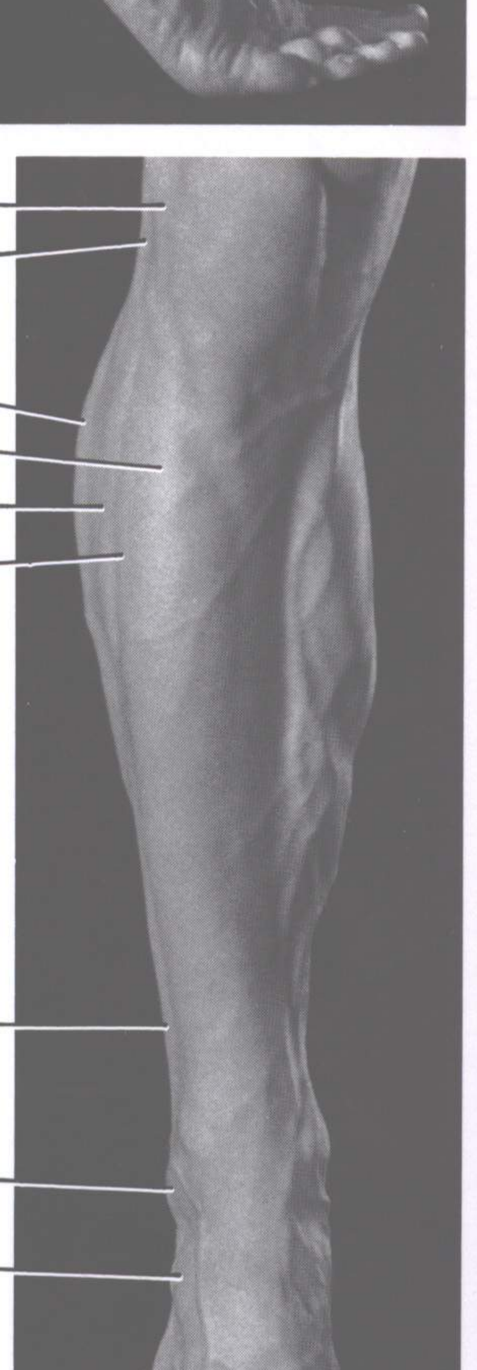




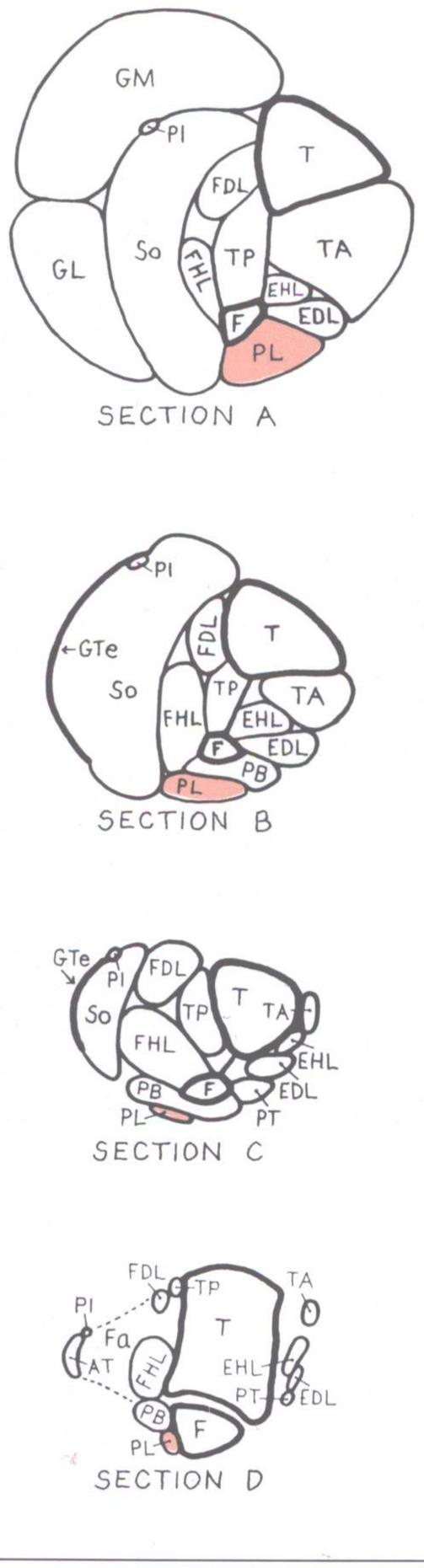








AT *Achilles tendon* **BFS** *Biceps femoris—short head* **EDB** *Extensor digitorum brevis*
EDL *Extensor digitorum longus* **F** *Fibula* **FHL** *Flexor hallucis longus* **HF** *Head of fibula*
ItT *Iliotibial tract* **LM** *Lateral malleolus* **PB** *Peroneus brevis* **PL** *Peroneus longus* **PT** *Peroneus tertius*
So *Soleus* **T** *Tibia* **TA** *Tibialis anterior*



Peroneus Longus

ORIGIN Lateral surfaces of the head and upper two-thirds of the shaft of the fibula, a small area on the lateral condyle of the tibia, and the intermuscular septa on both sides of the muscle.

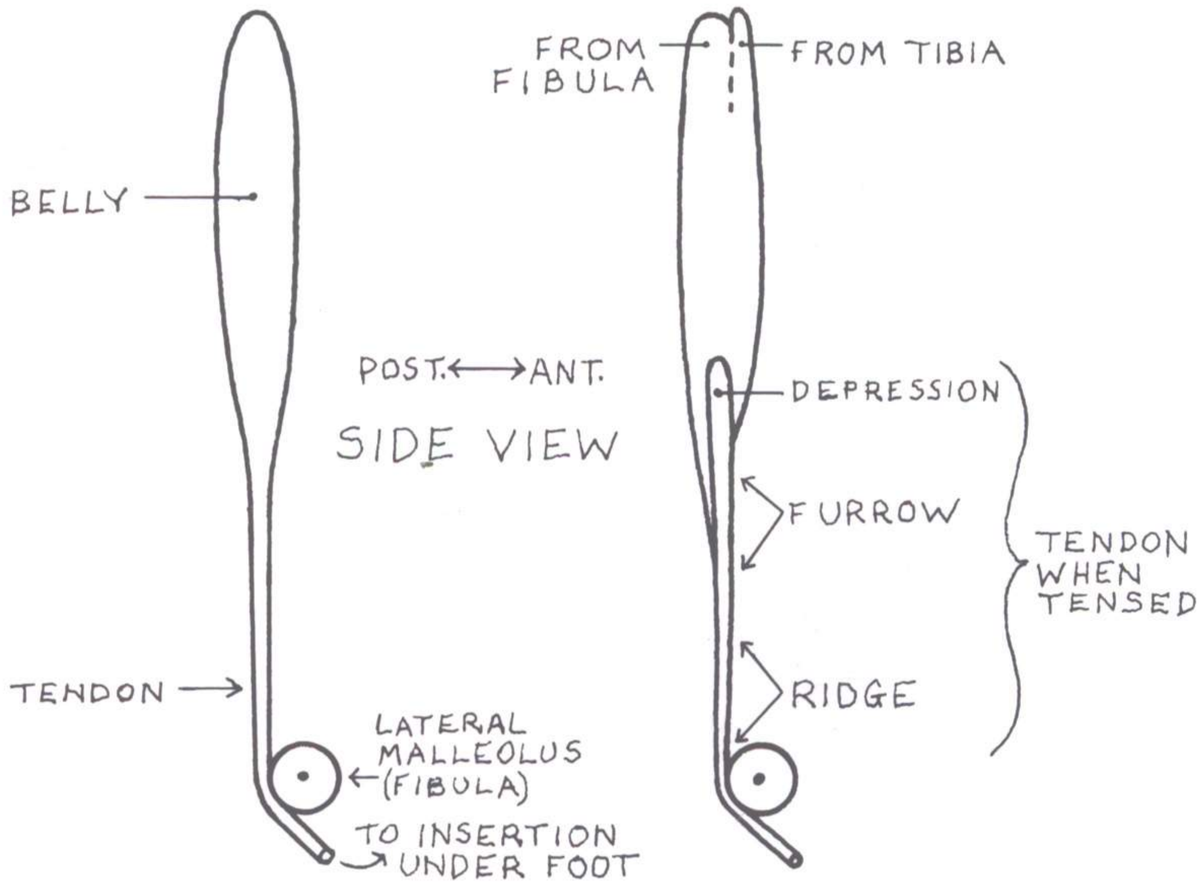
INSERTION Under the foot into the base of the metatarsal bone of the big toe and into the medial cuneiform (tarsal) bone.

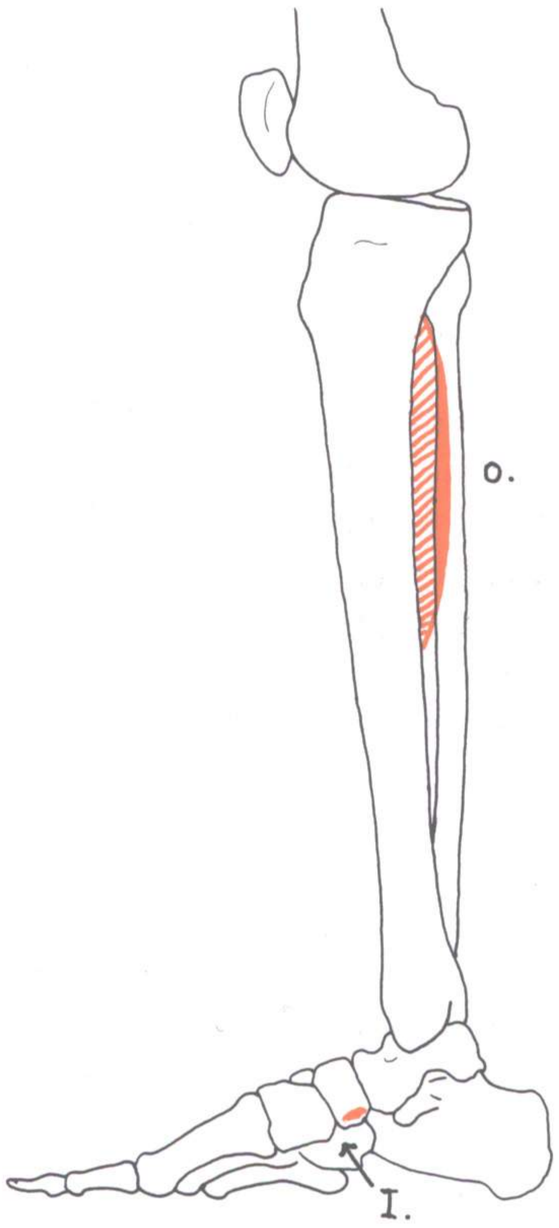
ACTION Everts and plantar flexes the foot. Important in maintaining the arches of the foot.

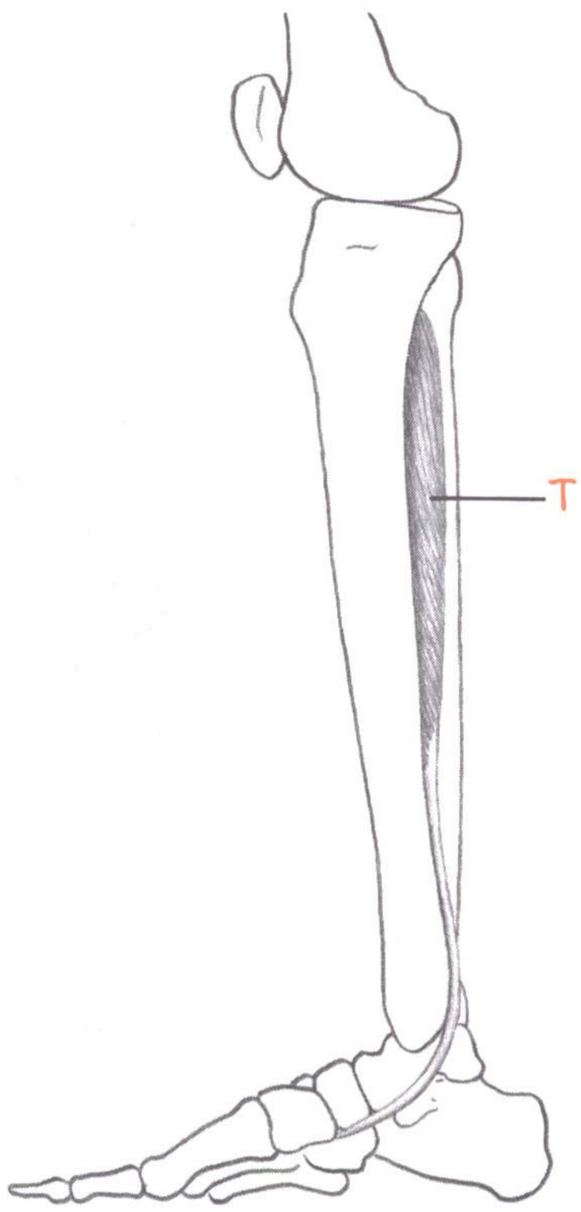
STRUCTURE The flattened, elongated, ovoid muscle belly of the peroneus longus sits on the upper half of the outside of the lower leg, while its tendon lies on top of the peroneus brevis on the lower half of the leg. The tendon begins approximately at the middle of the outside of the lower leg. The anterior fibers of the belly insert into the tendon's anterior edge for a short distance at the upper end of the tendon, whereas the posterior fibers continue further, inserting into the posterior edge of the tendon at a level two-thirds to three-quarters of the way down the lower leg (sometimes they continue all the way to the lateral malleolus).

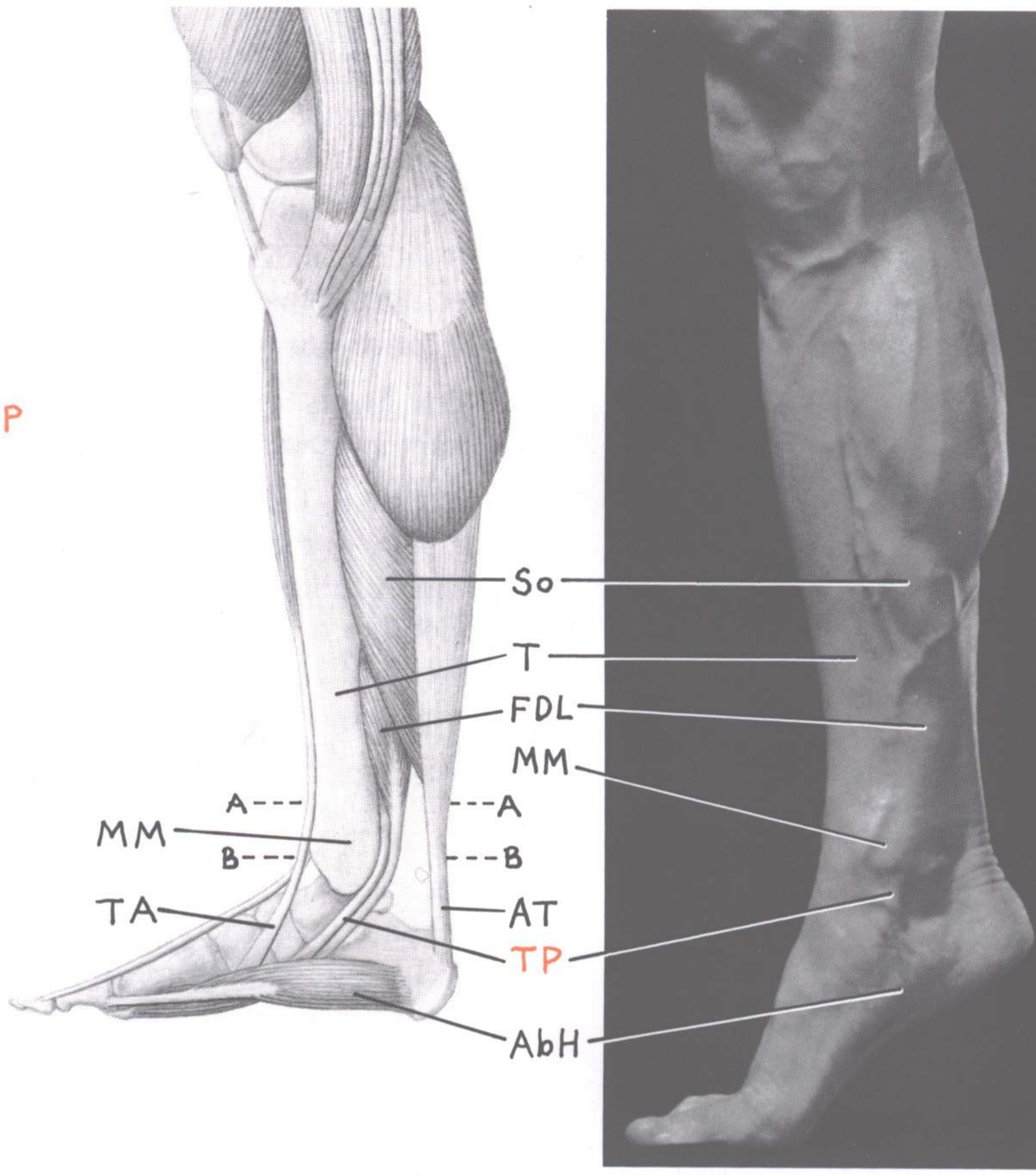
When relaxed, the peroneus longus and brevis combine to create a single elongated form on the outside of the lower leg, directed downward *behind* the lateral malleolus. When tensed, the two muscles differentiate, and the superior end of the *tendon* of the peroneus longus becomes depressed where its muscle fibers attach into it. The upper portion of the tendon then registers as a vertical furrow separating the belly of the peroneus brevis into narrow anterior (larger) and posterior (smaller) vertical bulges. The lower portion of the peroneus longus tendon becomes a prominent vertical raised ridge passing downward behind the lateral malleolus of the fibula. At the ankle, the tendon remains visible as it passes down the bony groove on the back of the lateral malleolus, posterior and superficial to the tendon of the peroneus brevis. It hooks forward on the outside of the foot below the lateral malleolus, running parallel yet heading deeper than the peroneus brevis tendon. It finally disappears as it curves under the outside of the skeleton of the foot to head toward its insertion. Except for a short distance immediately below the lateral malleolus, the tendon of the peroneus longus is usually less prominent on the outside of the foot than is the tendon of the peroneus brevis.

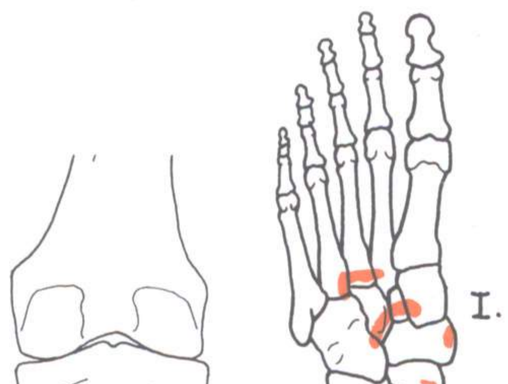
The outside profile of the upper half of the lower leg (from the front view) is usually caused by the soleus, not the peroneus longus. The small portion of the peroneus longus that attaches to the lateral condyle of the tibia may show up as a distinct thin form when the muscle is contracted. Also, the anterior one-fourth of the muscle belly and its tendon may occasionally separate into what appears to be a distinct, thin muscle.

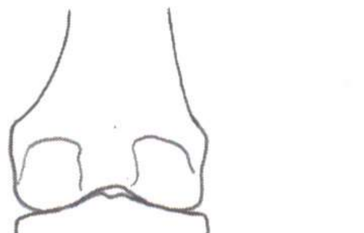


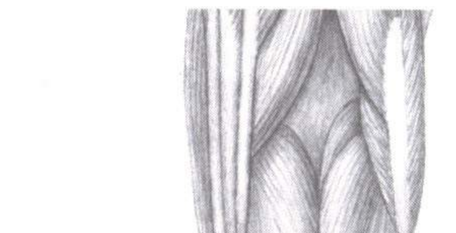


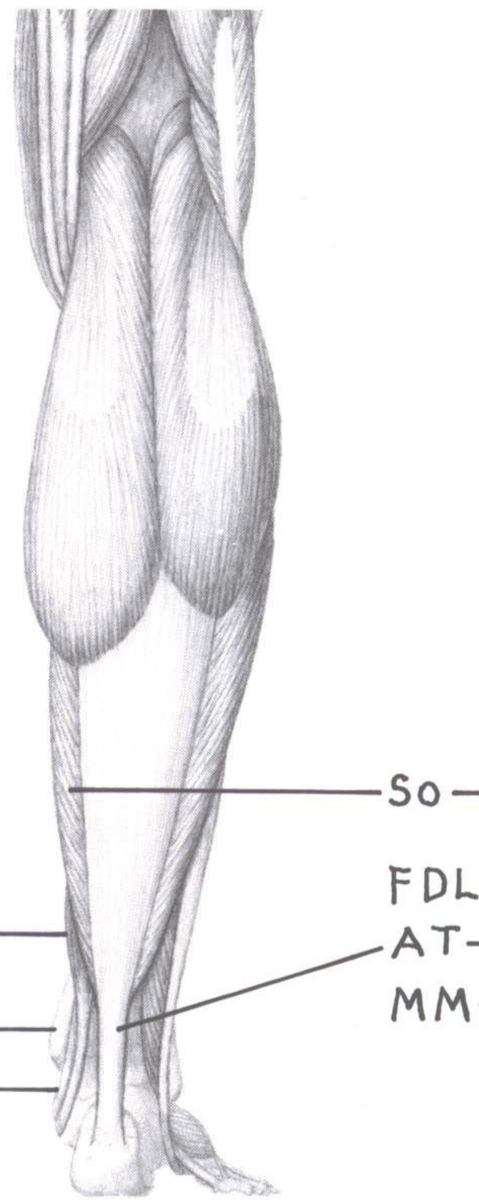


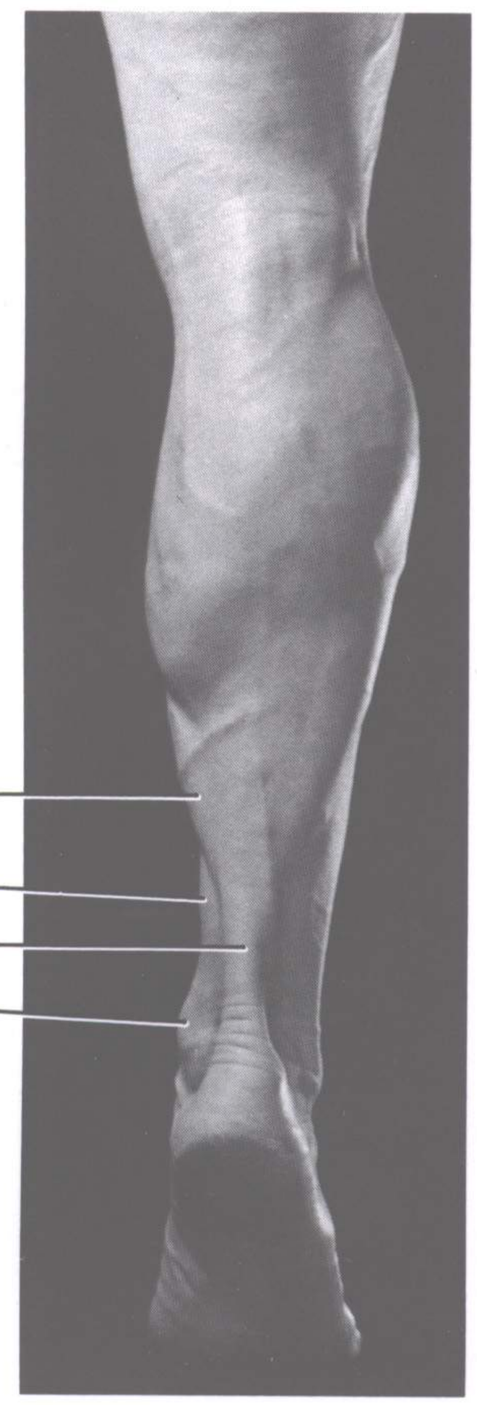




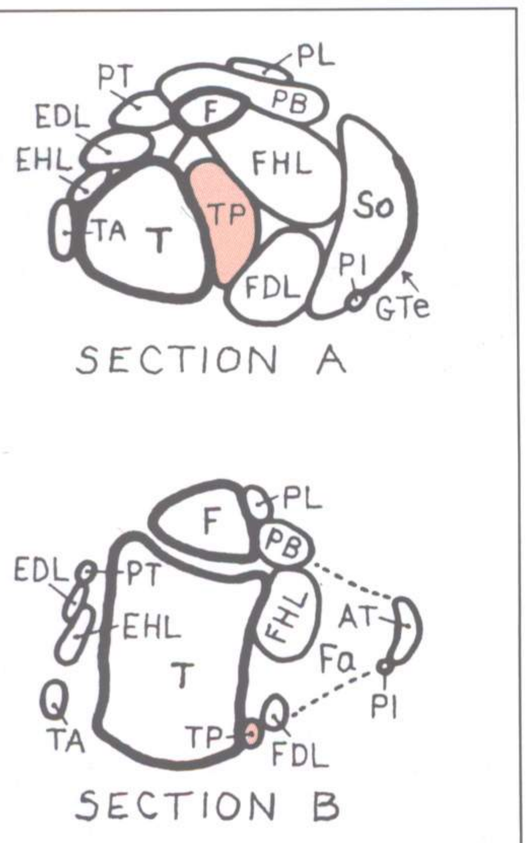








AbH *Abductor hallucis* **AT** *Achilles tendon* **F** *Fibula* **FDL** *Flexor digitorum longus*
FHL *Flexor hallucis longus* **MM** *Medial malleolus* **So** *Soleus* **T** *Tibia* **TA** *Tibialis anterior*
TP *Tibialis posterior*



Tibialis Posterior

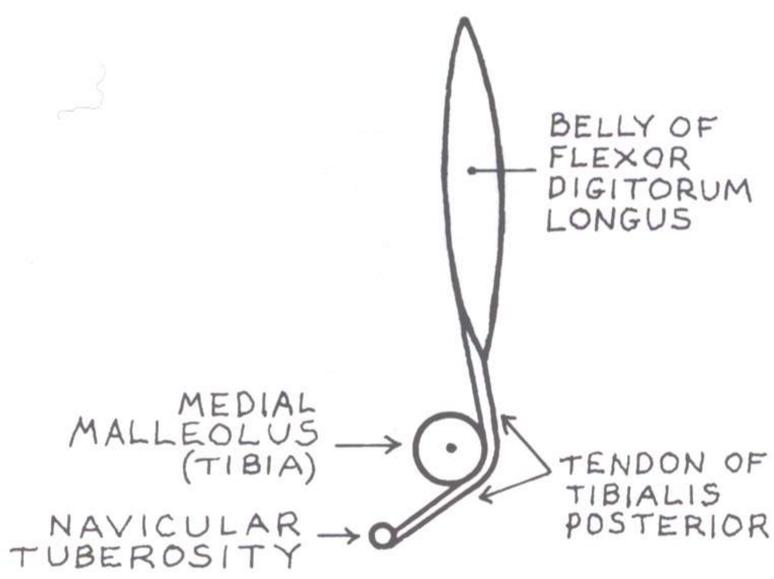
ORIGIN Lateral half of the posterior surface of the tibia, from below the lateral condyle to a point two-thirds of the way down the bone; the upper two-thirds of the medial surface of the fibula; and the interosseous membrane between these two bony origins.

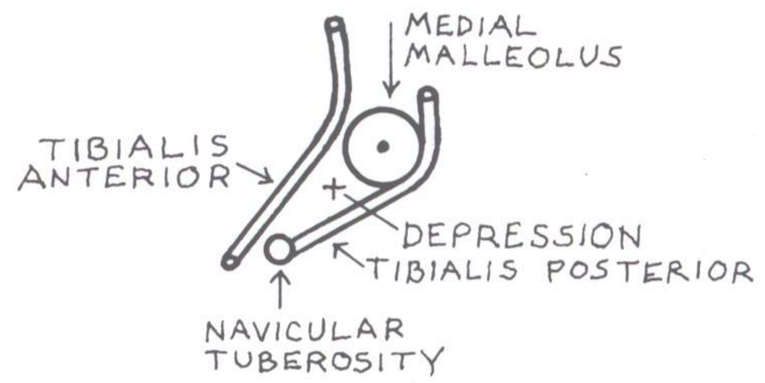
INSERTION Deep, into the bottom (plantar surface) of the middle of the foot skeleton—variously into six tarsal bones (navicular, three cuneiforms, cuboid, and talus) and the bases of the second, third, and fourth metatarsals. The visible tendon, on the inside of the ankle, is seen directed to its insertion on the navicular bone just below the prominent navicular tuberosity. The tendon then continues onward to expand under the foot, out of view.

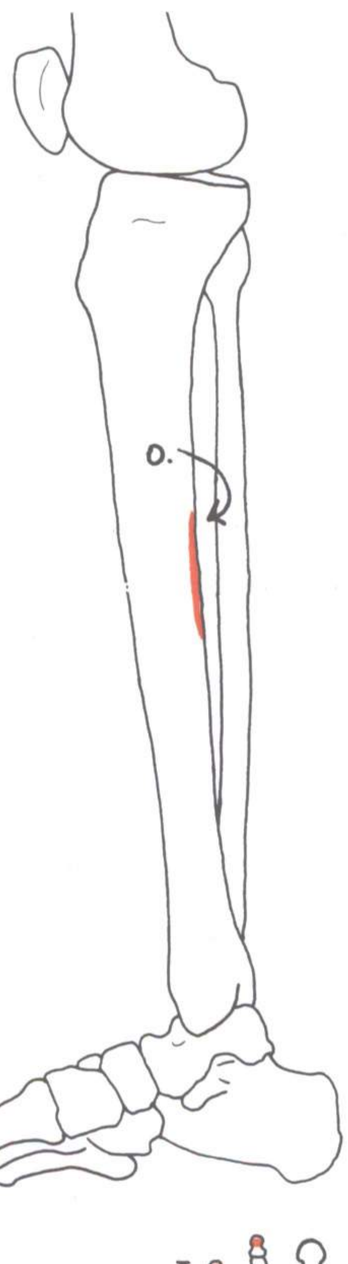
ACTION Plantar flexes and inverts the foot. It is the strongest support of the longitudinal arch of the foot.

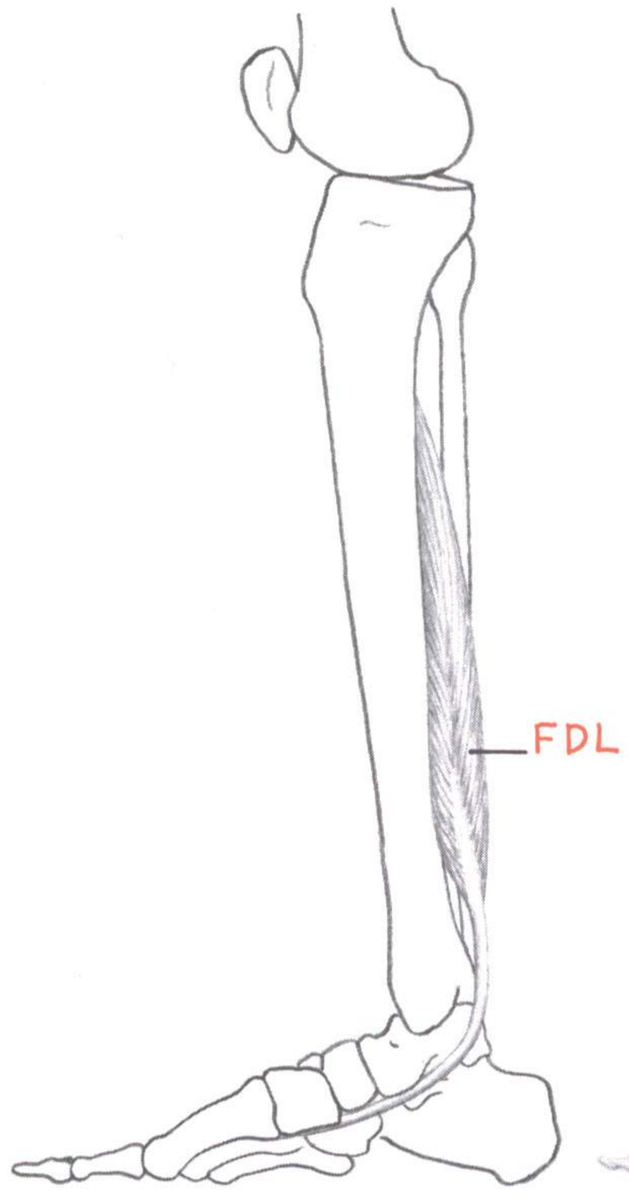
STRUCTURE Beginning deep at the upper end of the back of the lower leg, only the tendon of the tibialis posterior is superficial and visible for a short distance above, behind (lying in its bony groove), and below the medial malleolus. Its deep muscle belly and tendon run diagonally downward and medially, deep to the more vertical flexor digitorum longus. Just above the ankle, the oblique tendon of the tibialis posterior emerges superficially on the medial side of the vertical flexor digitorum longus. It is most prominent from where it angles forward below the medial malleolus to where it disappears under the prominence of the tuberosity of the navicular bone, on the medial side of the foot. Deep under the foot the tendon fans out as it inserts.

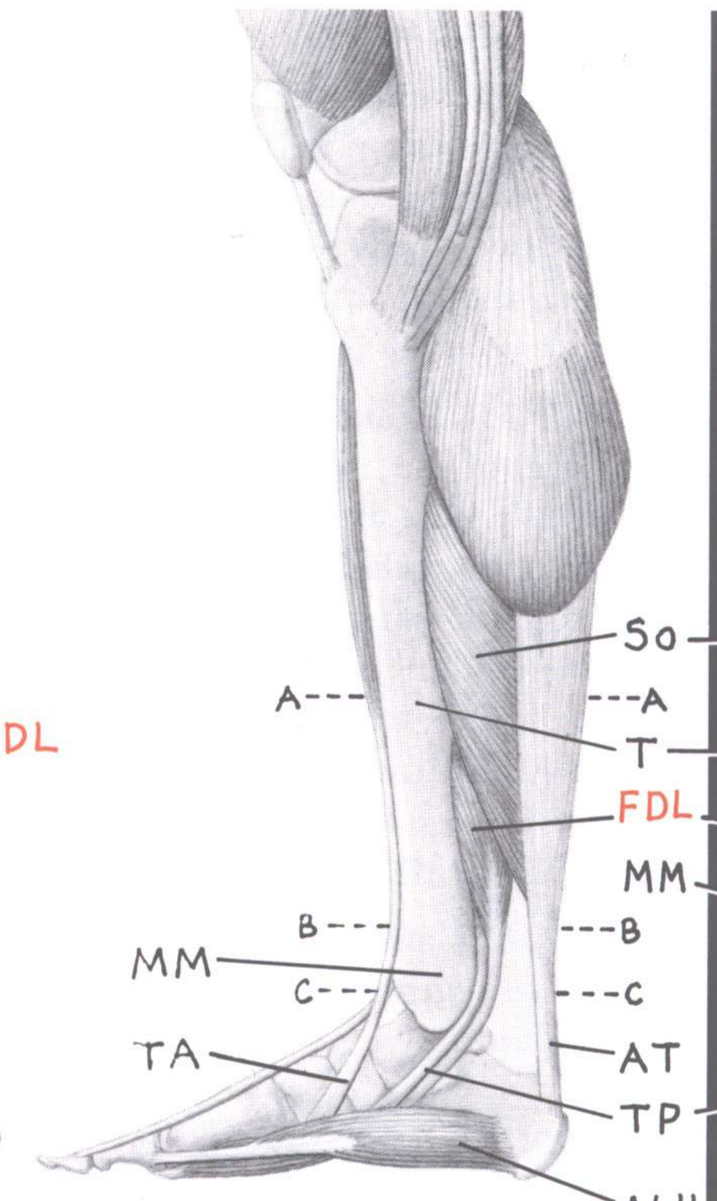
When the foot is inverted, the tendons of the tibialis anterior and posterior can be seen converging distally. A depression forms between them in front of the medial malleolus.

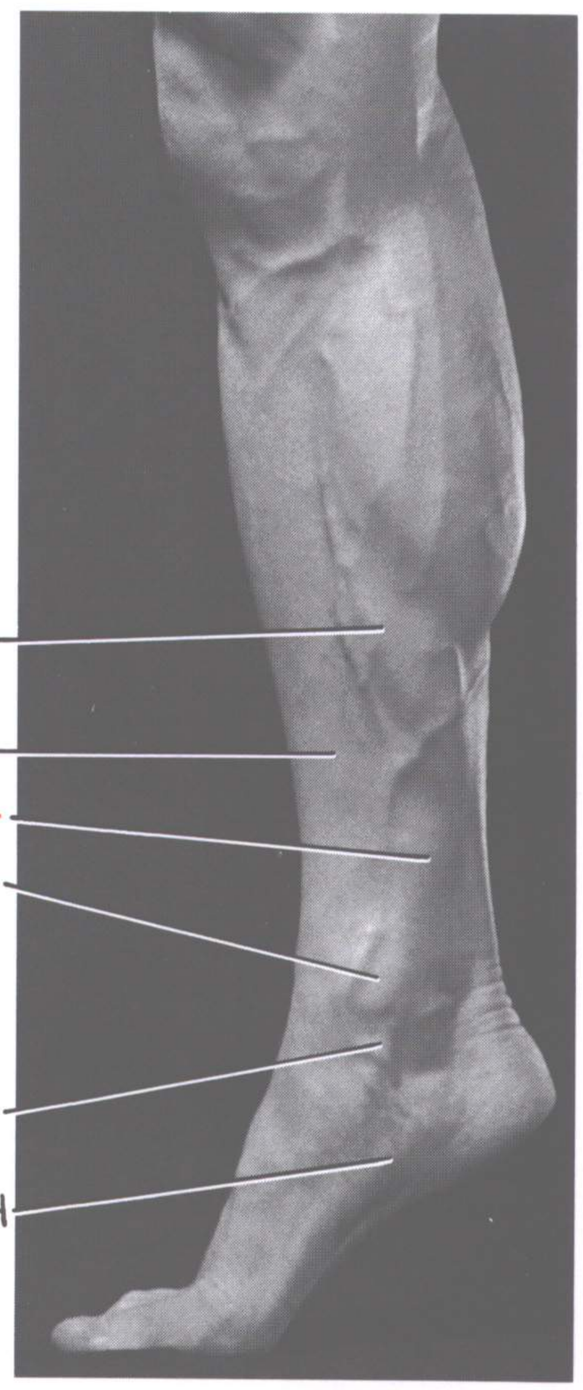


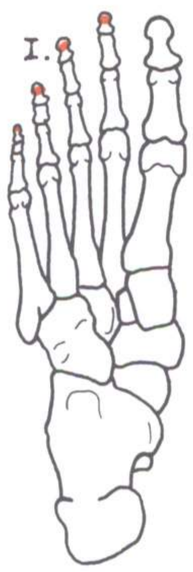


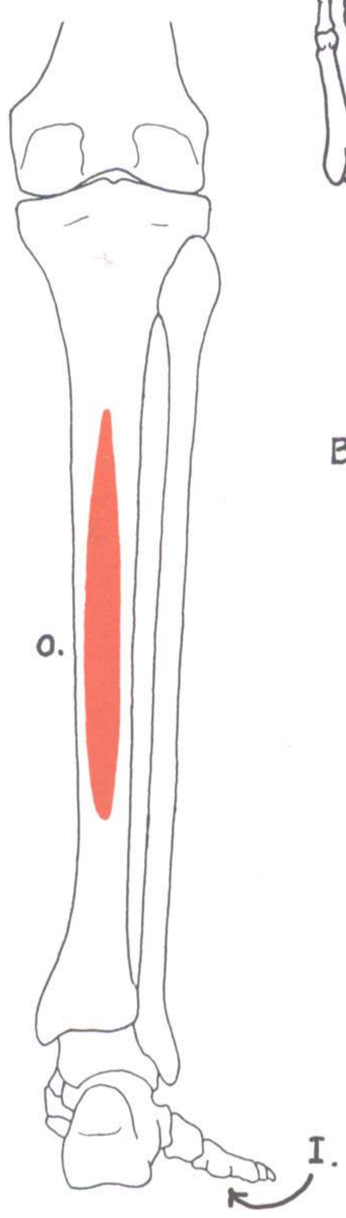




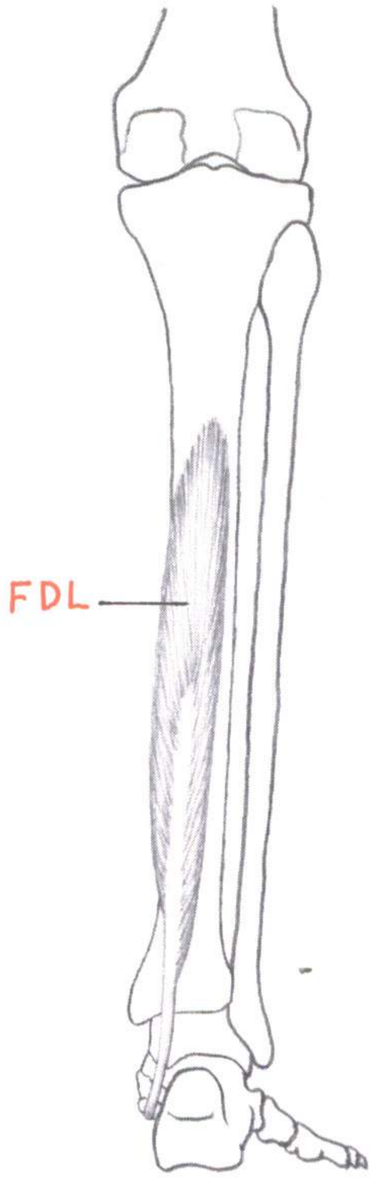


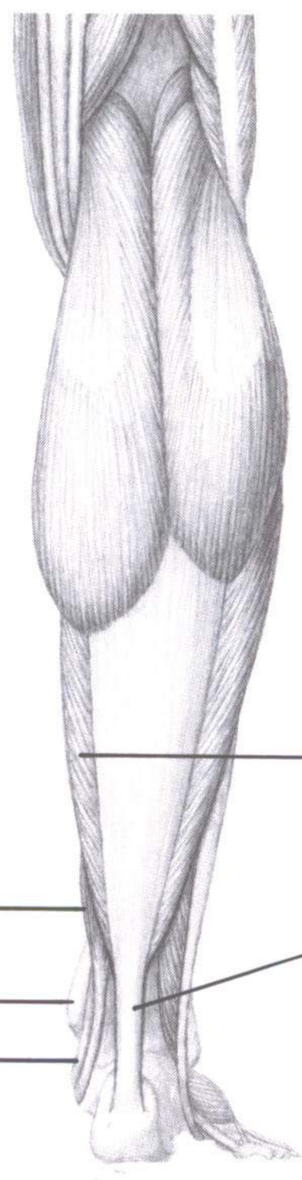


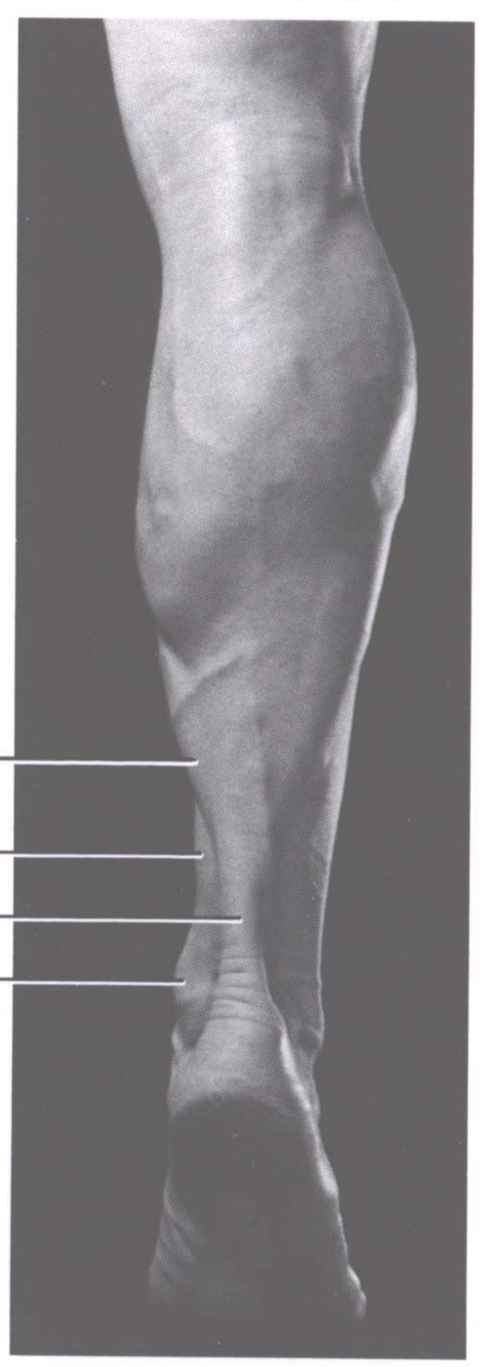




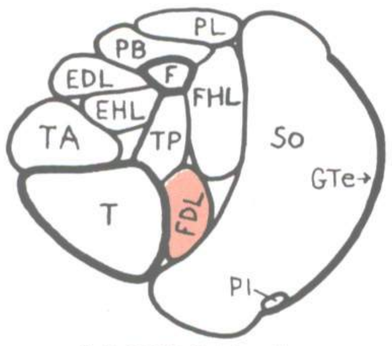
BOTTOM VIEW



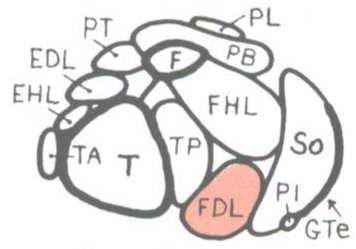




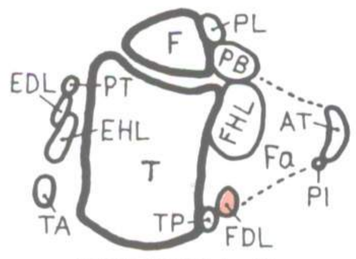
AbH *Abductor hallucis* **AT** *Achilles tendon* **F** *Fibula* **Fa** *Fat* **FDL** *Flexor digitorum longus* **FHL** *Flexor hallucis longus* **MM** *Medial malleolus* **So** *Soleus* **T** *Tibia* **TA** *Tibialis anterior* **TP** *Tibialis posterior*



SECTION A



SECTION B



SECTION C

Flexor Digitorum Longus

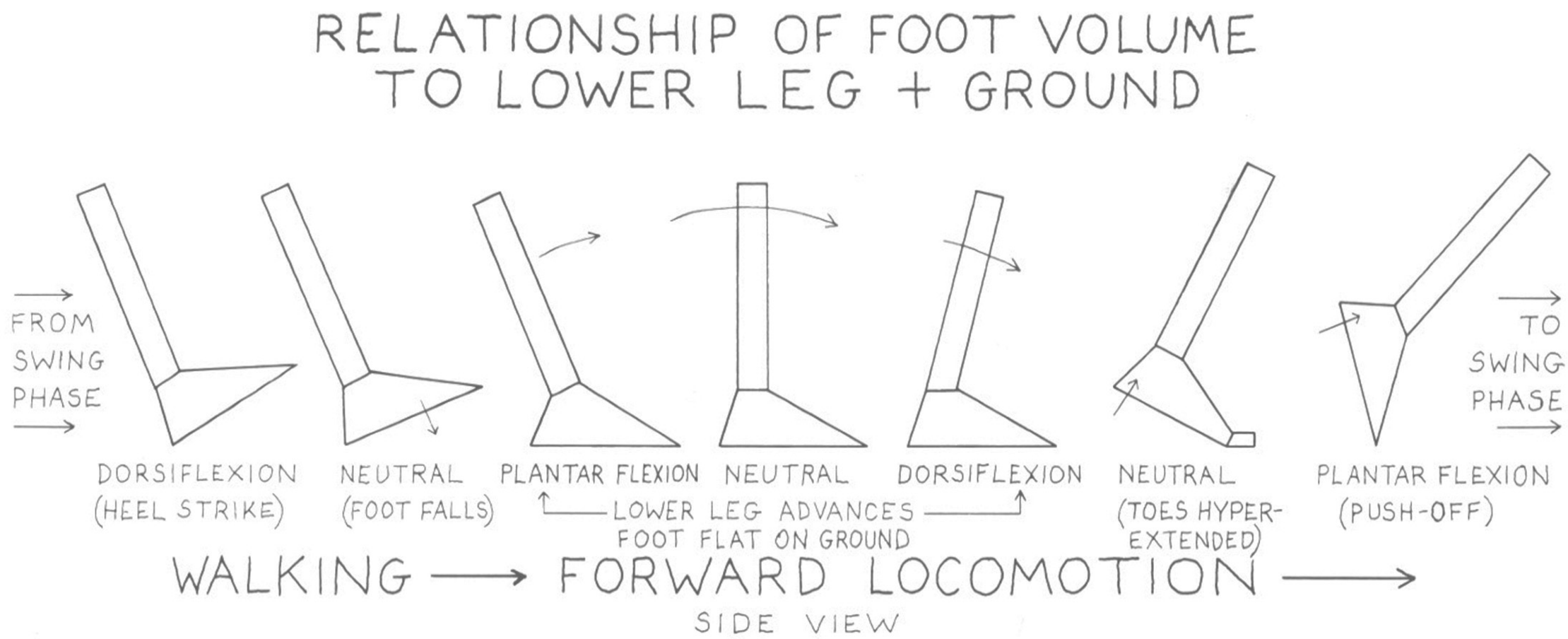
ORIGIN Middle half of the back surface of the shaft of the tibia, beginning just below the soleal line.

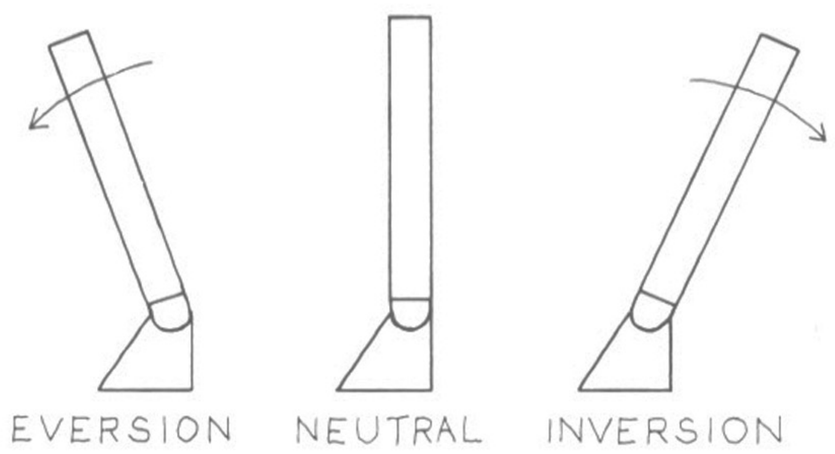
INSERTION Bases of the distal phalanges of toes two through five on their plantar surfaces (*not* into the big toe).

ACTION Flexes the distal phalanges of the lateral four toes, especially for the final push-off in walking and running. By continued action, it plantar flexes and inverts the foot.

STRUCTURE Beginning deep in the lower leg on the back of the tibia, and ending deep under the foot, only a small portion of the belly of the flexor digitorum longus is subcutaneous on the lower third of the inside of the lower leg, just posterior to the medial surface of the shaft of the tibia. It is not distinct, but rather fills a small area between the tibia and lower anterior edge of the soleus. The exposed muscle fibers taper into a tendon that becomes concealed as it shifts away from the surface, lateral to the tendon of the tibialis posterior, which has now emerged from between the tibia and flexor digitorum longus and become superficial. The tendon of the flexor digitorum longus then curves behind the pulley of the medial malleolus (in the same bony compartment as the tibialis posterior tendon) and divides into the four tendons heading to the lateral four toes. Although the tendon of the flexor digitorum longus lies adjacent to but on a slightly deeper plane than the conspicuous tendon of the tibialis posterior, it is not seen.

The flexor digitorum longus is attached to the deep **flexor hallucis longus** muscle (flexor of the big toe) under the foot by a tendinous slip. When the toes are alternately flexed and extended together, the inferior ends of the bellies of both these muscles can be seen rising and descending just behind and below the medial malleolus. A noticeable depression is created between the medial malleolus and Achilles tendon when the toes are fully flexed. Even though the flexor hallucis longus is deep, the ascent of the inferior end of its belly affects surface form. Because of the tendinous connection between them, the flexor hallucis longus and flexor digitorum longus must be flexed together to achieve *full* flexion of all the toes.


RELATIONSHIP OF FOOT VOLUME
TO LOWER LEG + GROUND
FROM SWING PHASE
DORSIFLEXION (HEEL STRIKE)
NEUTRAL (FOOT FALLS)
PLANTAR FLEXION
NEUTRAL
DORSIFLEXION
LOWER LEG ADVANCES FOOT FLAT ON GROUND
NEUTRAL (TOES HYPER-EXTENDED)
PLANTAR FLEXION (PUSH-OFF)
TO SWING PHASE
WALKING → FORWARD LOCOMOTION →
SIDE VIEW


EVERSION
NEUTRAL
INVERSION
FOOT FLAT ON GROUND
SIDE-TO-SIDE MOVEMENT OF LOWER LEG
FRONT VIEW

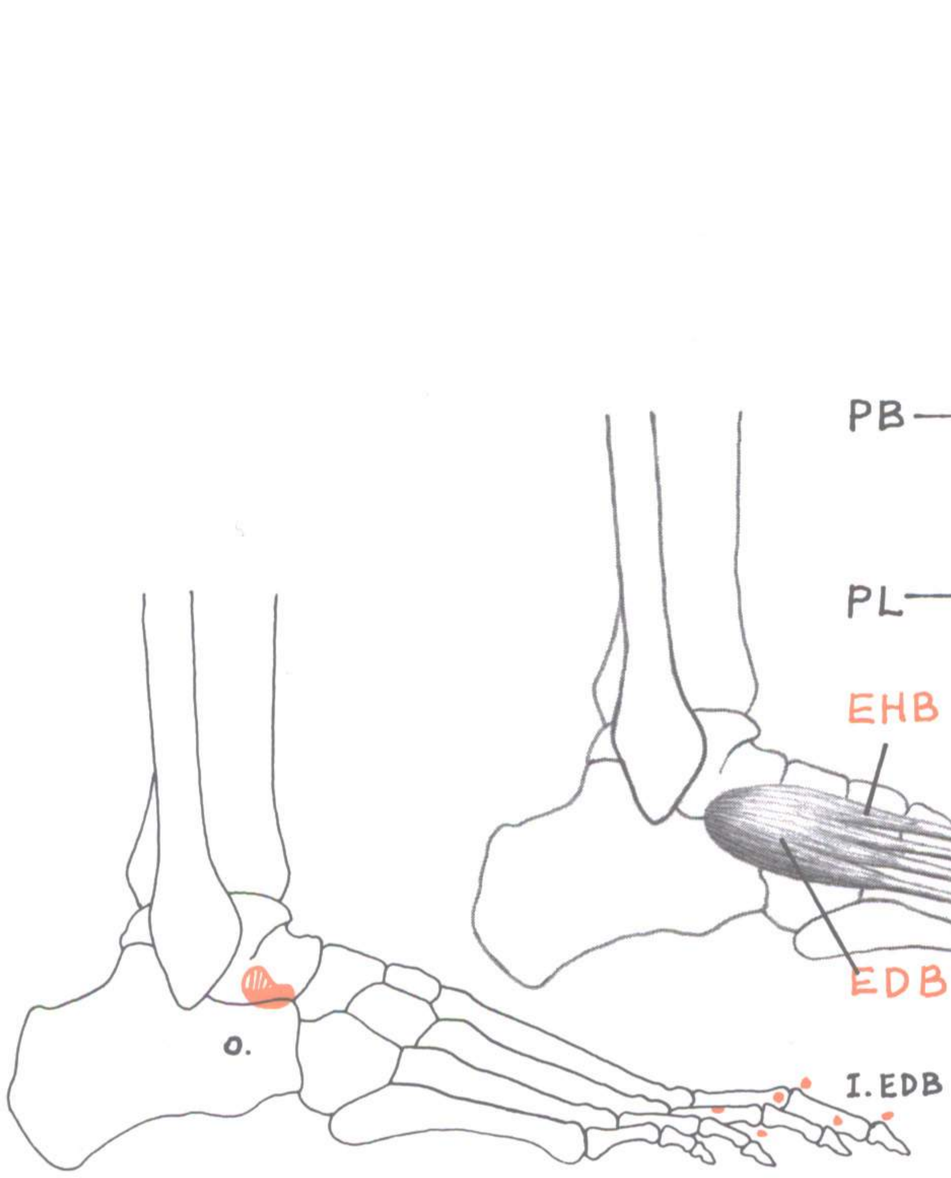
The Foot Muscles

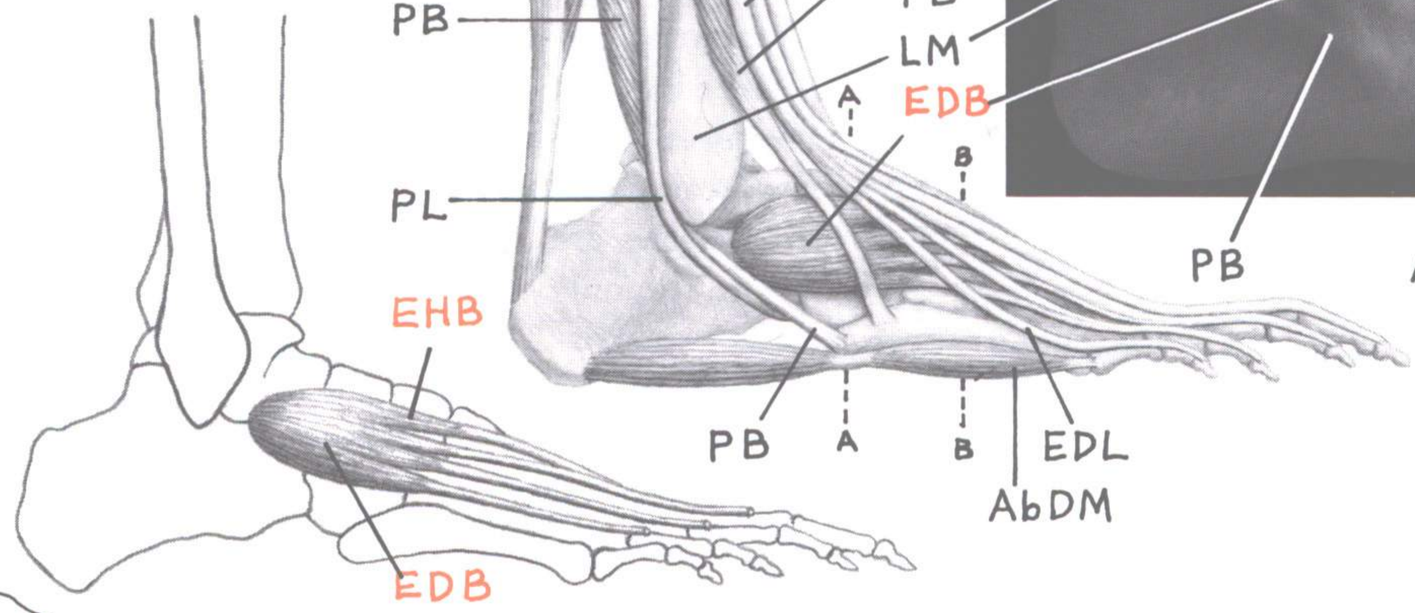
The *FOOT,* or pes, can be visualized as a triangular volume or an irregular pyramid. It is hard, bony, and tendinous on its upper or dorsal surface and flat and cushioned with fibrous fat on its sole, or plantar aspect.

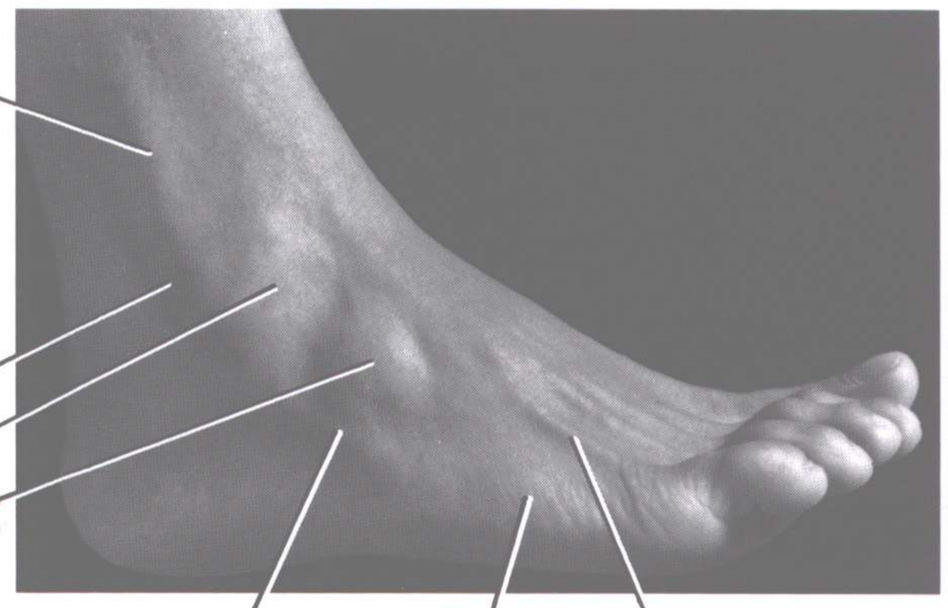
The **extrinsic muscles** of the foot originate on the lower leg, and their bellies are located there as well. Their tendons, which cross the ankle joint, are located on the foot. These muscles are described in the section on the lower leg. The **intrinsic muscles** of the foot arise from the foot itself and have their fleshy bellies located within its confines. Most of the intrinsic muscles are located deep to the sole of the foot. The only ones that are regularly seen are the extensor digitorum brevis and the combined form of the abductor hallucis and flexor hallucis brevis. The form of the abductor digiti minimi is concealed for the most part by the plantar fat, which blends with its form.

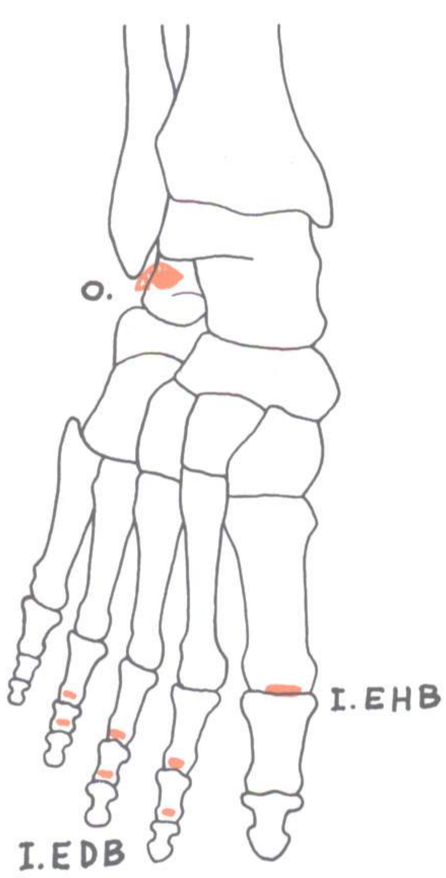
The foot is designed as a base of support for the body above, as a shock absorber during impact, and most importantly, as a propulsion lever to move the body during locomotion. Although actions of the foot are often visualized in terms of movement of the free foot, during normal activity, the foot is planted on the ground and the lower leg (and the rest of the body) moves in relation to it (forward and back; side to side).

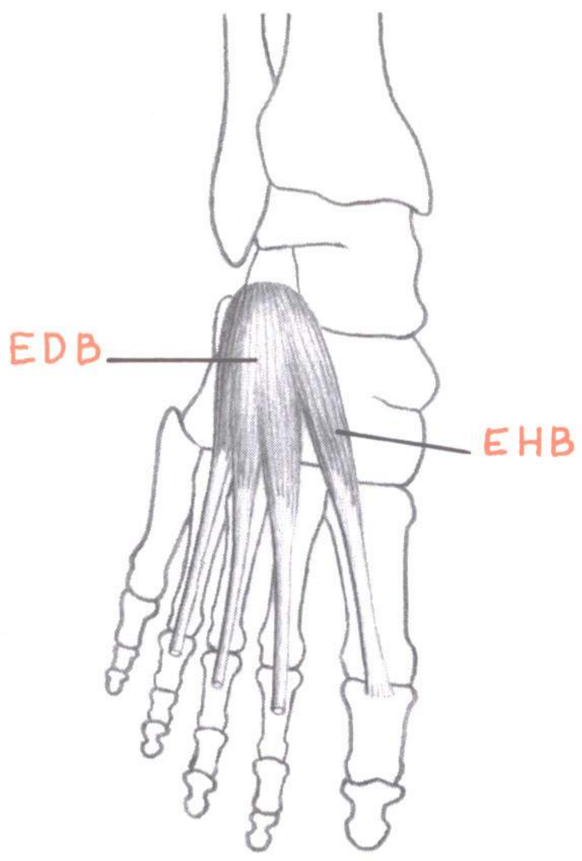
The **plantar aponeurosis** is a strong fibrous band of fascia that extends along the bottom of the foot. For the most part, it lies on top of the foot muscles, passing from the heel toward the toes. It assists in maintaining the longitudinal arches of the foot, as well as providing areas for muscle attachment. Its posterior end attaches to the medial process of the calcaneus, while the wider anterior end separates into five slips (one for each toe) before attaching into the skin superficially (at the base of each toe) and into the bases of the proximal phalanges.

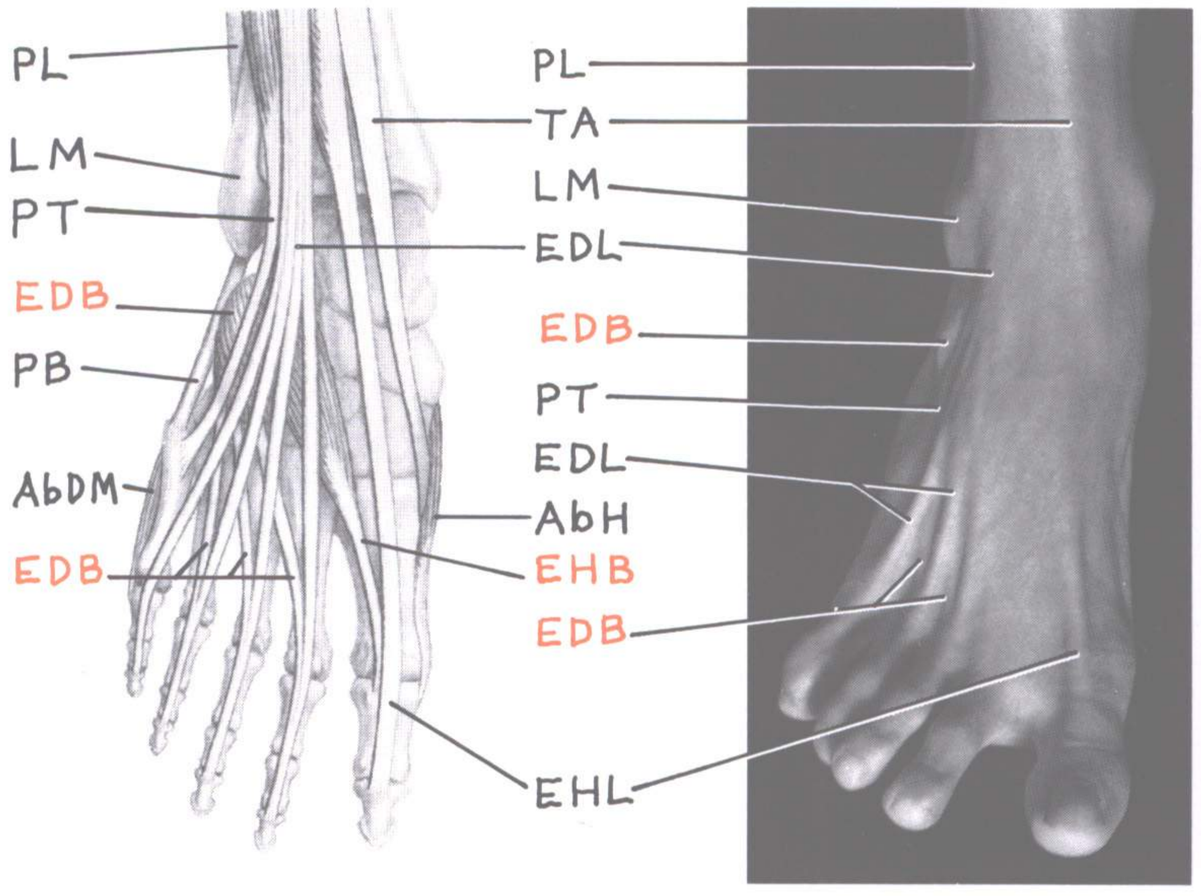




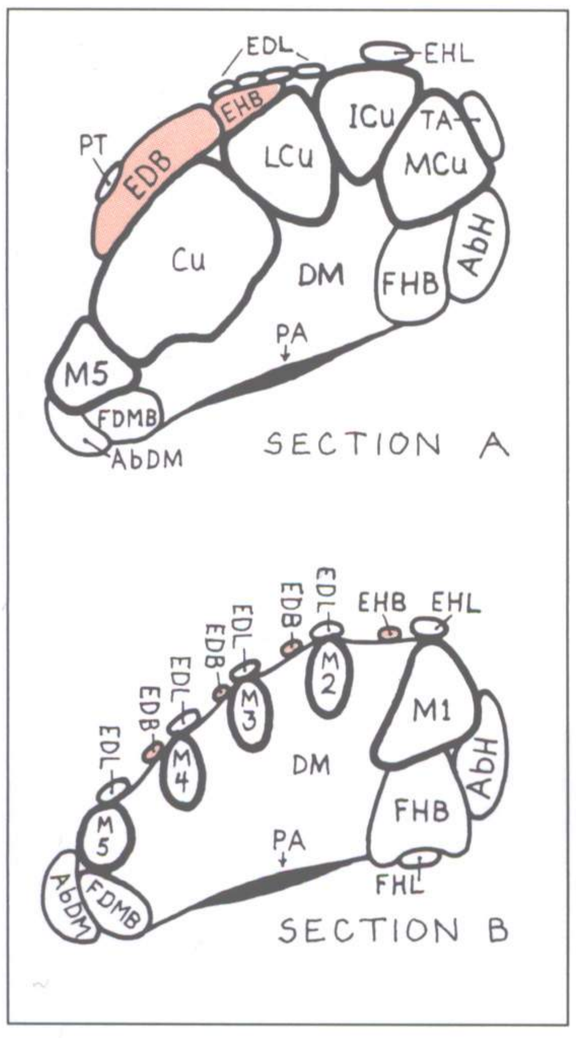








AbDM *Abductor digiti minimi* **AbH** *Abductor hallucis* **Cu** *Cuboid* **DM** *Deep muscle*
EDB *Extensor digitorum brevis* **EDL** *Extensor digitorum longus* **EHB** *Extensor hallucis brevis*
EHL *Extensor hallucis longus* **LCu** *Lateral cuneiform* **LM** *Lateral malleolus* **M** *Metatarsal*
PB *Peroneus brevis* **PL** *Peroneus longus* **PT** *Peroneus tertius* **TA** *Tibialis anterior*



Extensor Digitorum Brevis (including Extensor Hallucis Brevis)

ORIGIN *Entire muscle:* The upper surface of the front end of the calcaneus, the inferior extensor retinaculum, and the lateral talocalcaneal ligament.

INSERTION To the medial four toes as follows: **Extensor hallucis brevis** (to the big toe): *into bone;* it inserts into the upper surface of the base of the proximal phalanx of the big toe. **Extensor digitorum brevis** (to the middle three toes): *into tendon;* its tendons join the lateral sides of the tendons of the extensor digitorum longus heading to the second, third, and fourth toes. It therefore ultimately inserts into the middle and distal phalanges of the middle three toes. These tendon-to-tendon fusions occur on the top of the proximal phalanges.

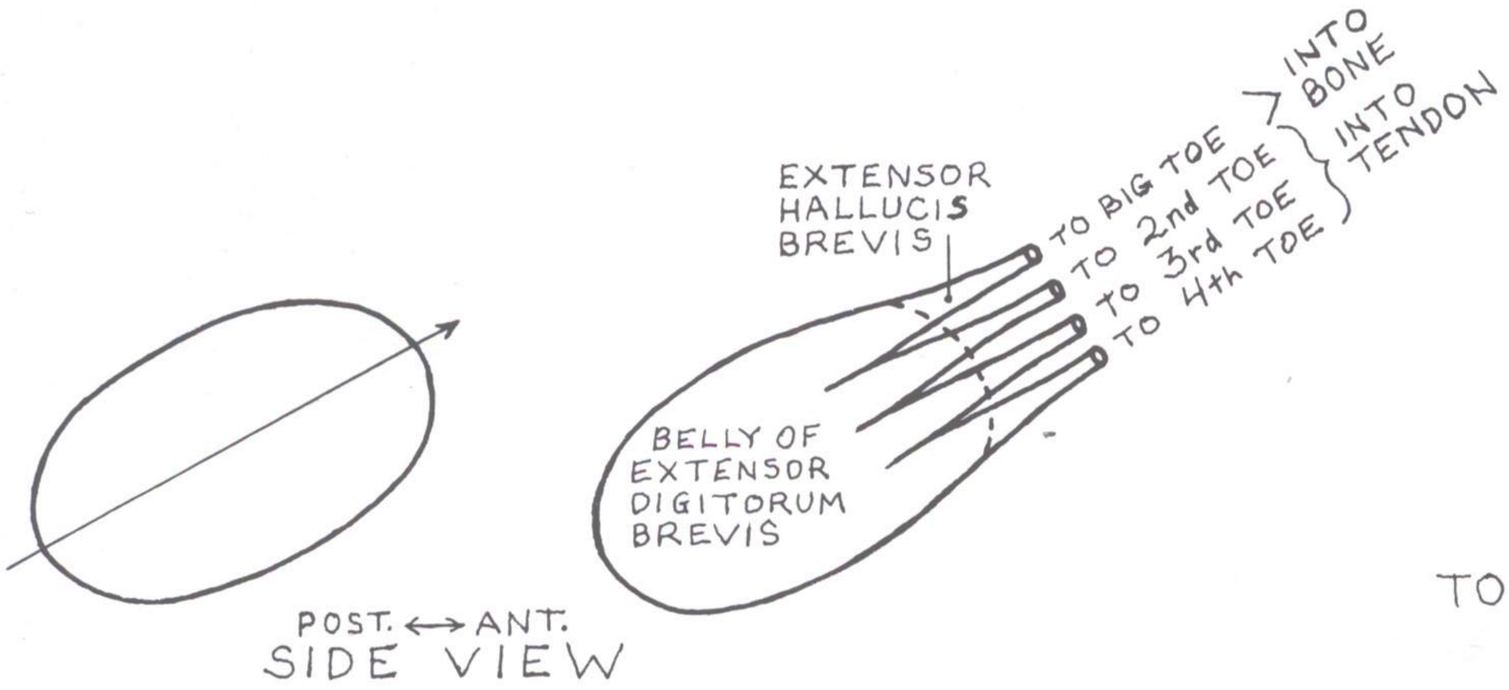
ACTION **Extensor hallucis brevis:** extends the proximal phalanx of the big toe. **Extensor digitorum brevis:** extends the phalanges of the second, third, and fourth toes at the interphalangeal and metatarsophalangeal joints; pulls these toes laterally at the metatarsophalangeal joints.

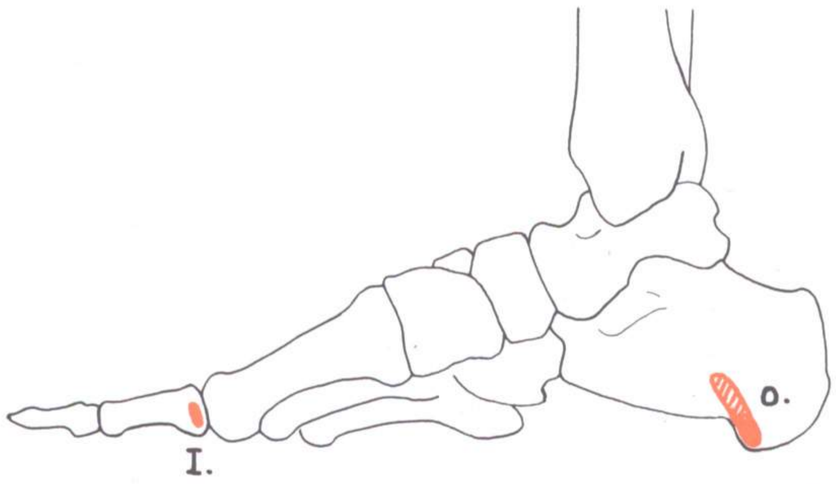
STRUCTURE The overall extensor digitorum brevis muscle is made up of four slender, flat bellies that pass forward and medially over the top of the foot. These bellies develop into tendons distally. The combined bellies create an oval bulge on the outside of the top of the foot, located below and in front of the lateral malleolus. The bulge, directed forward, upward, and medially, is always present, but the individual bellies and their tendons are only occasionally visible.

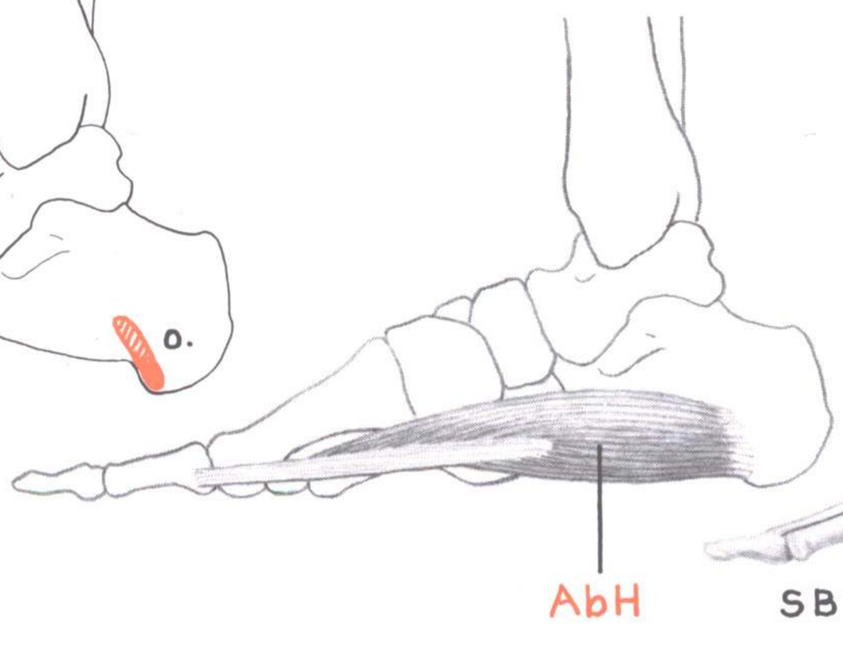
The most medial portion of the extensor digitorum brevis, inserting into the big toe, is also referred to as the **extensor hallucis brevis.** It differs from the other bellies of this muscle by inserting into bone, rather than into the sides of tendons. When the big toe is flexed, the narrow, flat belly of the extensor hallucis brevis may be seen on the dorsum of the foot, between the tendons of the extensor hallucis longus and extensor digitorum longus of the second toe. Although flexing the big toe will stretch the belly of the extensor hallucis brevis and make it thinner, it also pulls the belly distally, so it can be seen in the interval between the tendons that border it on the dorsum of the foot.

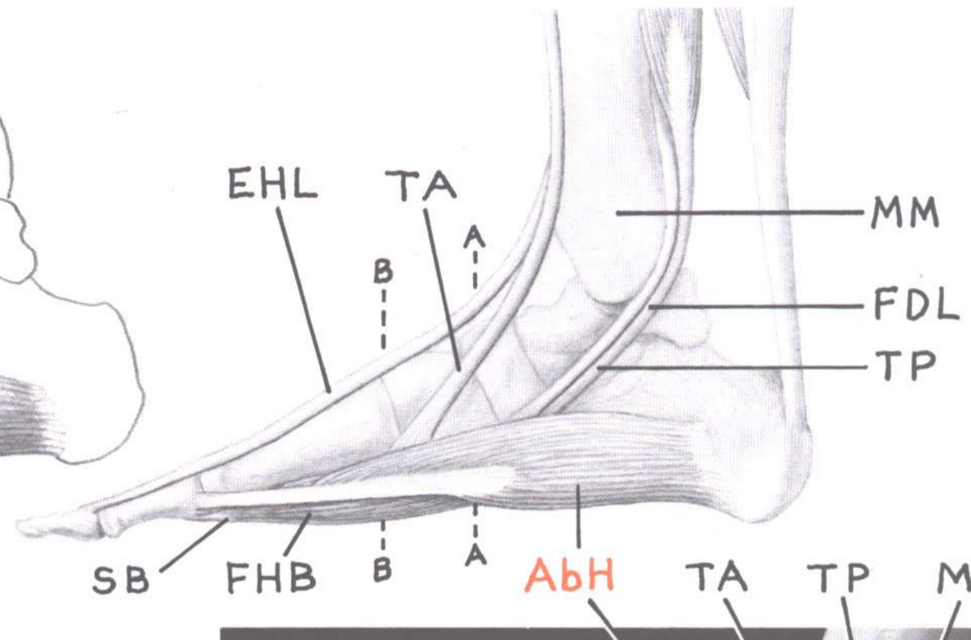
The tendons to the middle three toes can occasionally be seen on top of the distal half of the metatarsus, in the three spaces between the four long tendons of the extensor digitorum longus. These tendons of the extensor digitorum brevis are directed posteriorly toward the lateral malleolus, whereas the tendons of the extensor digitorum longus are directed toward the middle of the front of the ankle.

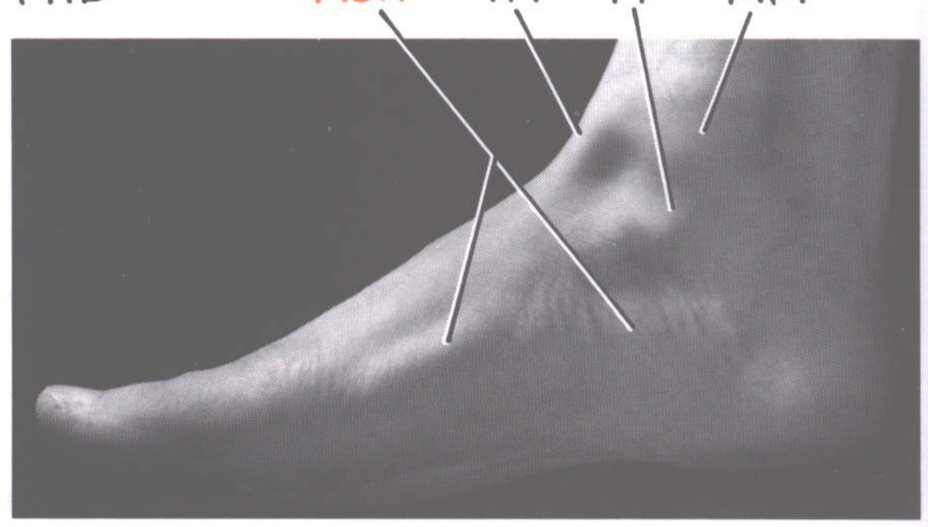
Note: The extensor digitorum brevis (including the extensor hallucis brevis) does not insert into the little toe; it inserts into the medial four toes only.

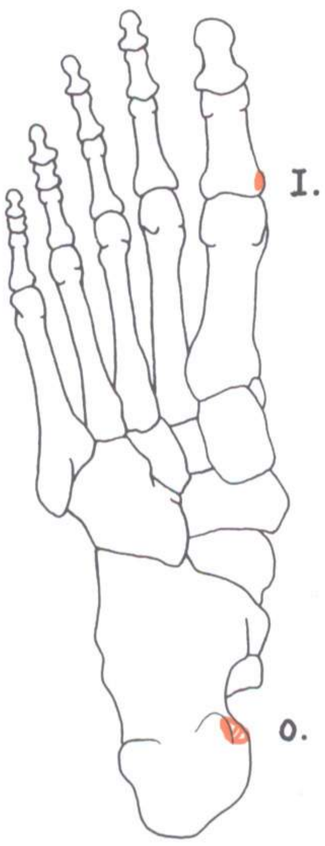


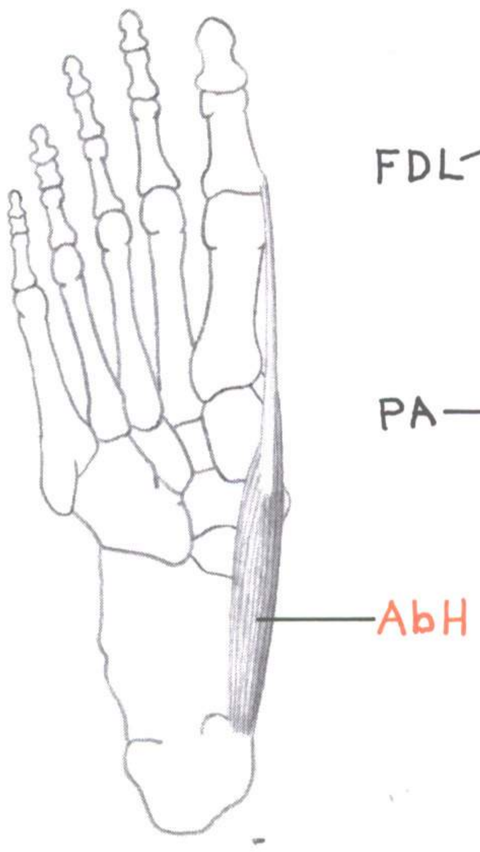


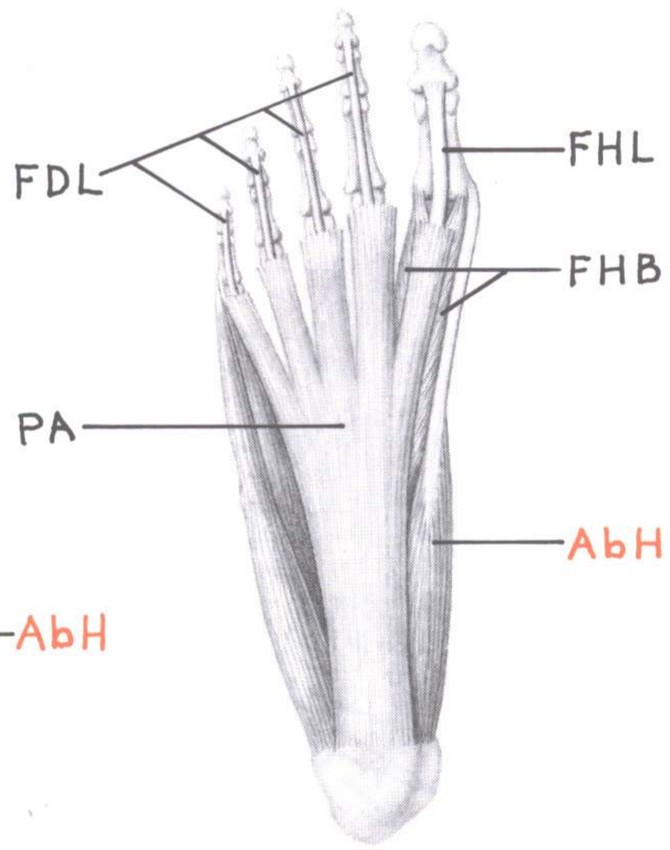


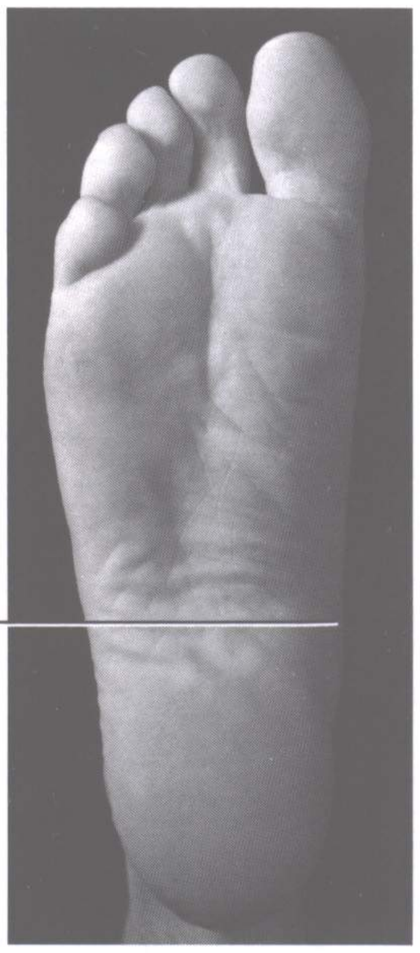




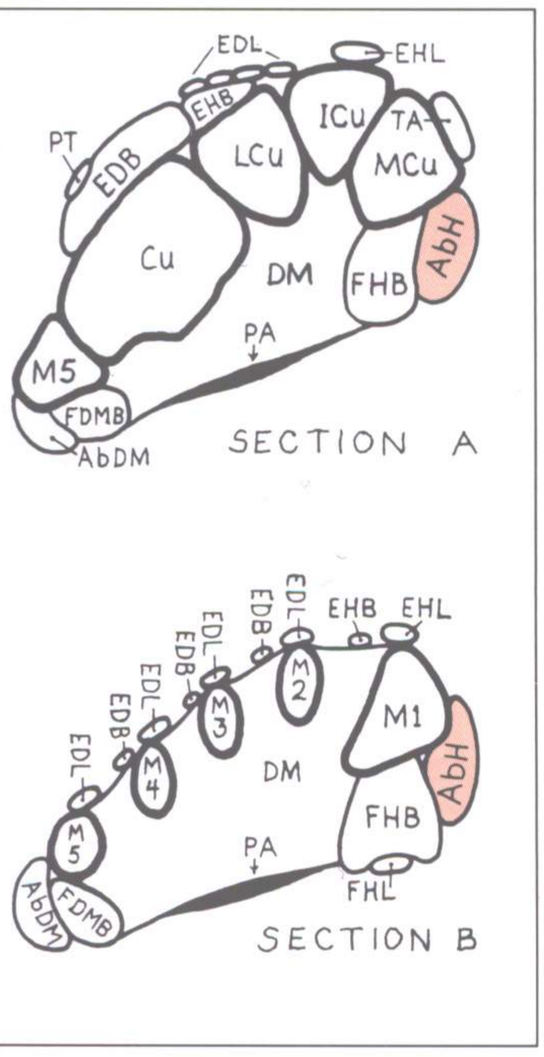








AbH *Abductor hallucis* **DM** *Deep muscle* **EHL** *Extensor hallucis longus*
FDL *Flexor digitorum longus* **FHB** *Flexor hallucis brevis* **FHL** *Flexor hallucis longus* **M** *Metatarsal*
MCu *Medial cuneiform* **MM** *Medial malleolus* **PA** *Plantar aponeurosis* **SB** *Sesamoid bone*
TA *Tibialis anterior* **TP** *Tibialis posterior*



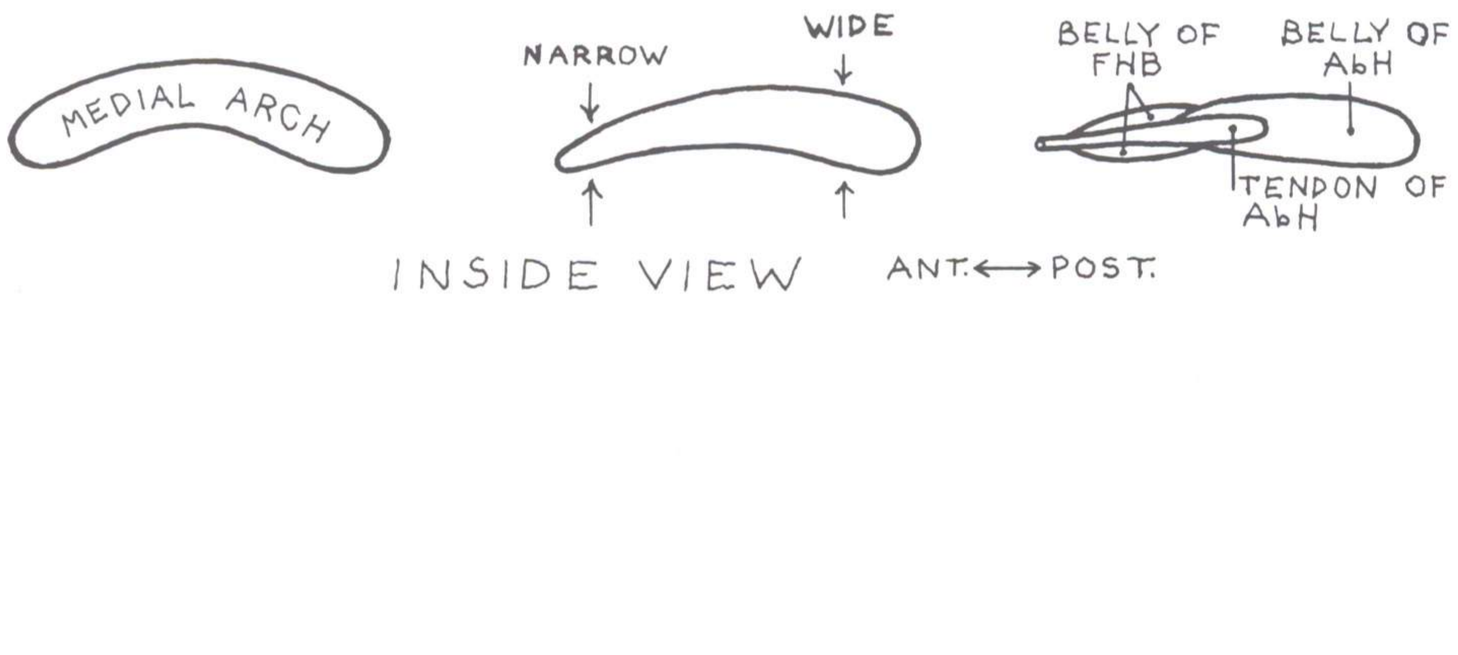
Abductor Hallucis

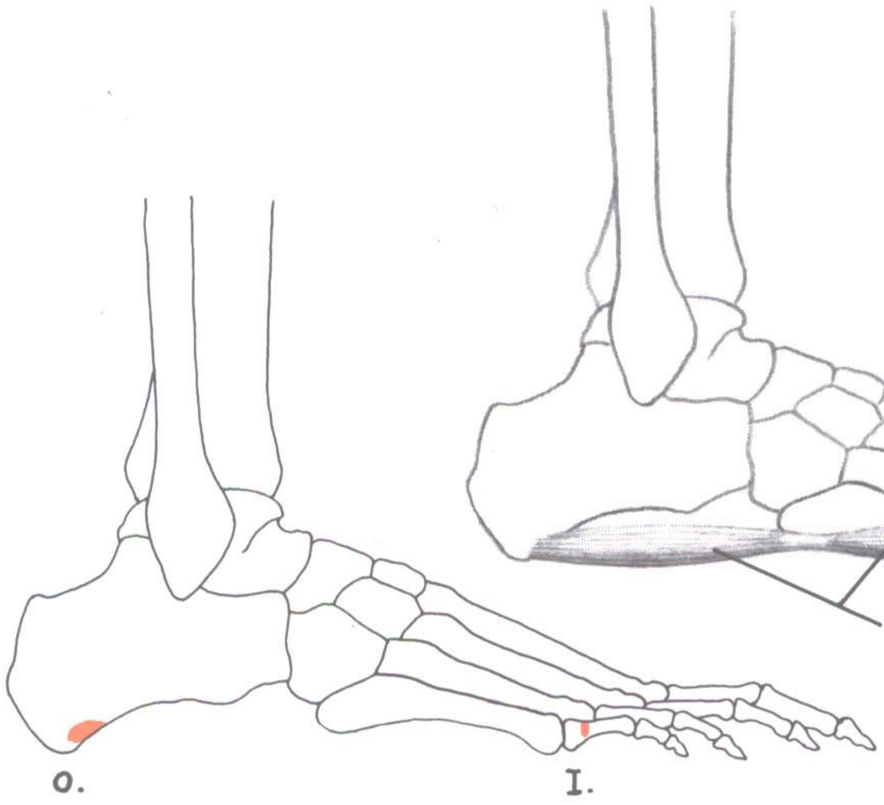
ORIGIN Medial process on the bottom of the calcaneus, the anterior edge of the flexor retinaculum of the ankle (stretching between the heel and medial malleolus), and the plantar aponeurosis.

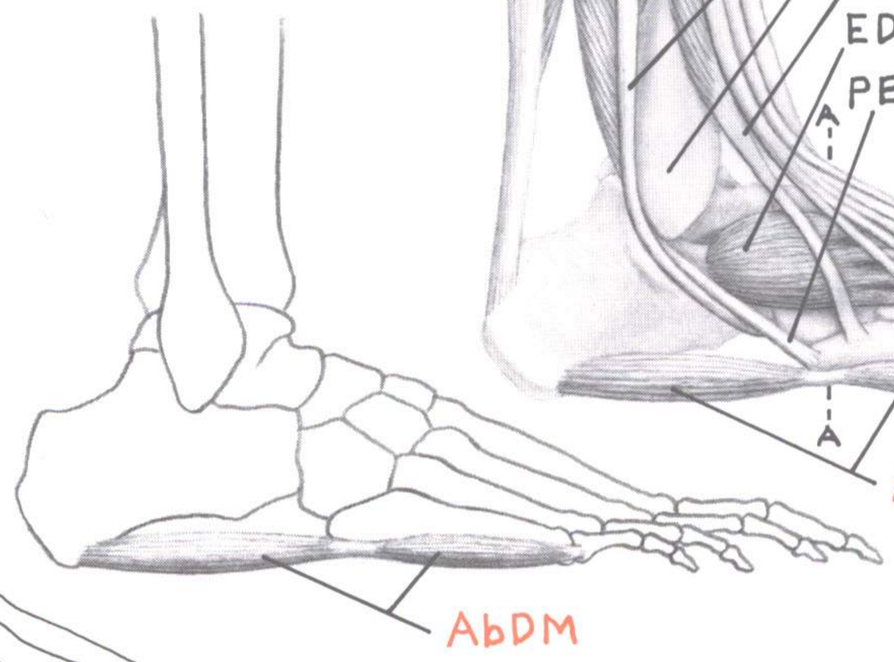
INSERTION Medial side of the base of the proximal phalanx of the big toe.

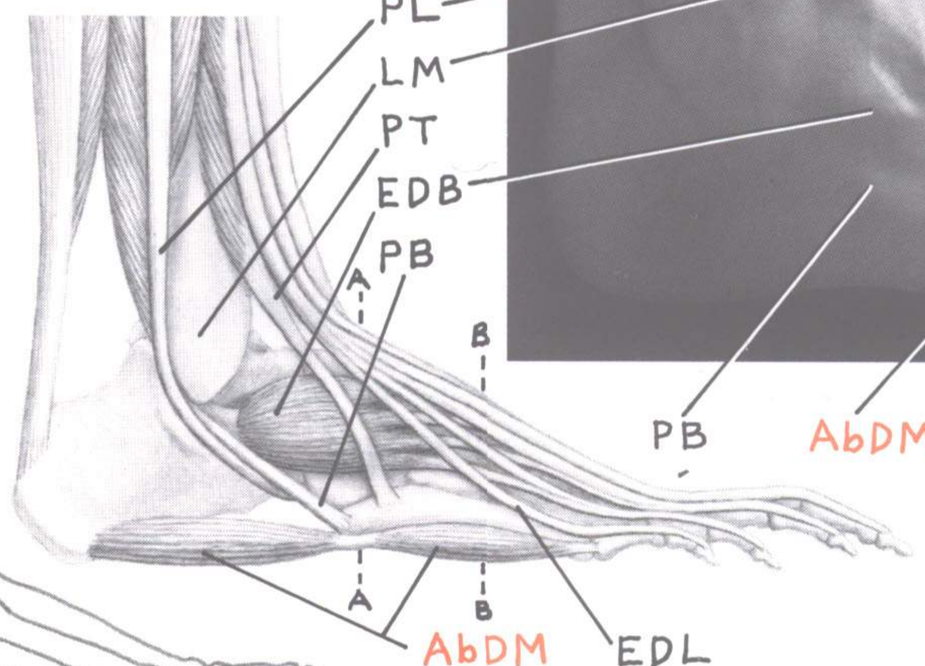
ACTION Flexes more than it actually abducts the metatarsophalangeal joint of the big toe.

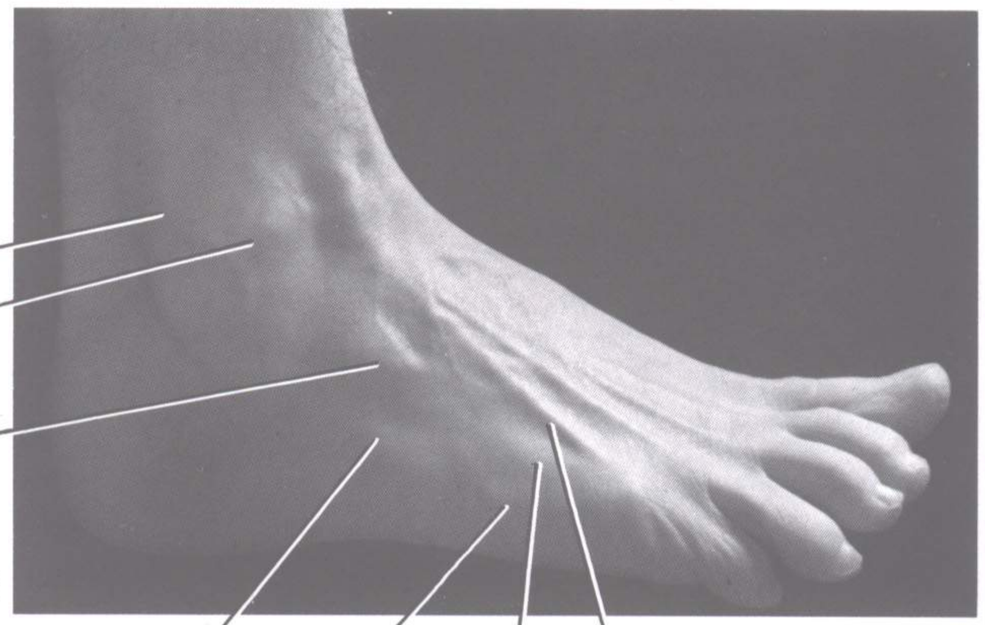
STRUCTURE The abductor hallucis begins from a wide origin near the posterior end of the inside of the foot. Its posterior two-thirds is fleshy muscle belly; the anterior third is tendon. Muscle fibers continue to insert along the top edge of the tendon for a variable distance. The abductor hallucis combines with the flexor hallucis brevis, which is located anteriorly under its tendon, to create a slight raised relief along the medial border of the foot. This form lies on the inner arch of the foot, below the tuberosity of the navicular bone, and curves upward at its center to conform to the rounded medial arch. Its elongated oblong form stretches from the heel to the metatarsophalangeal joint of the big toe.

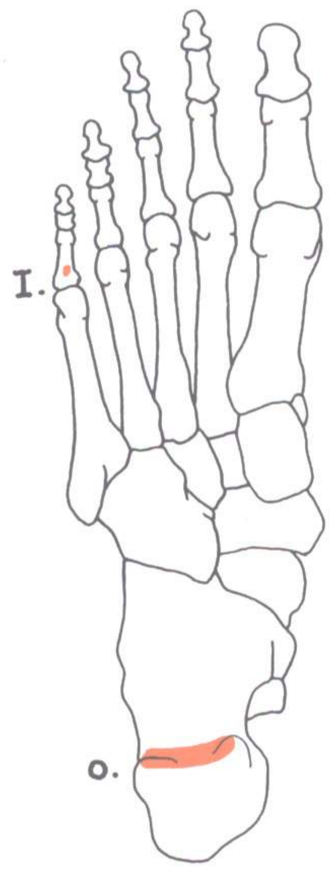


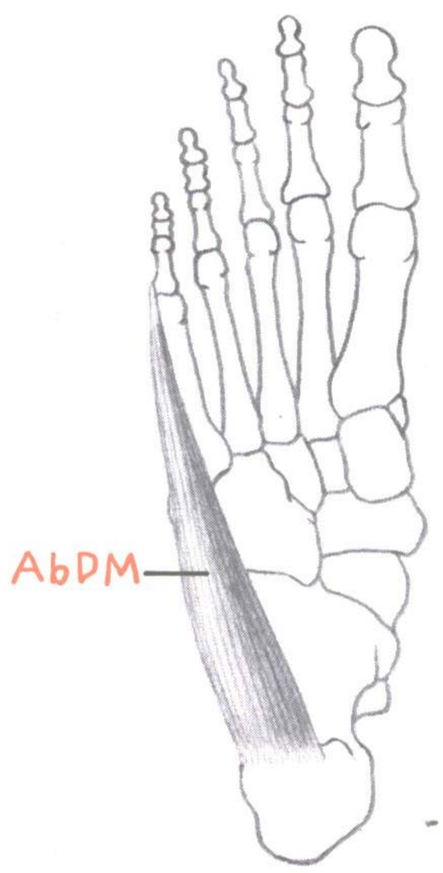


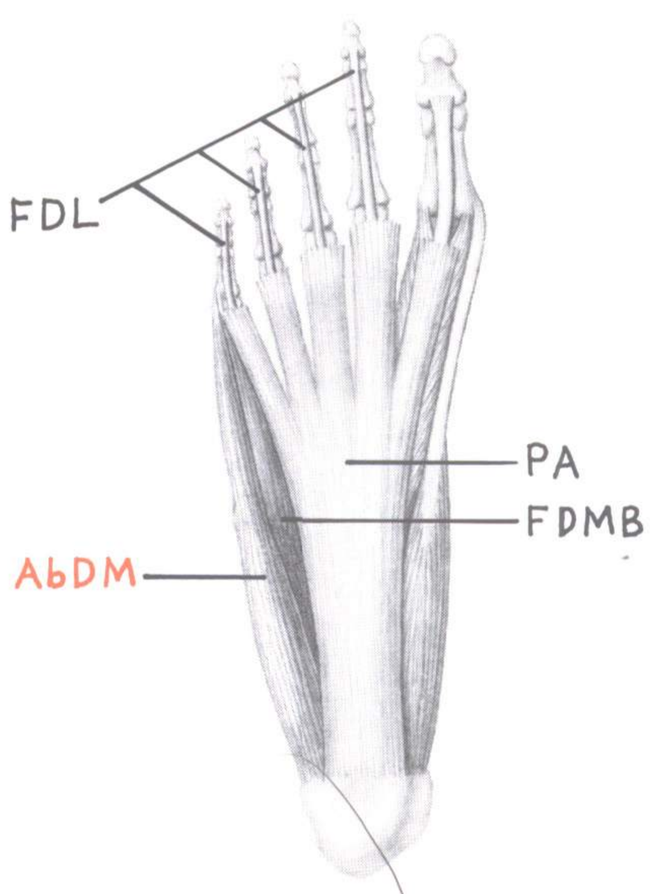


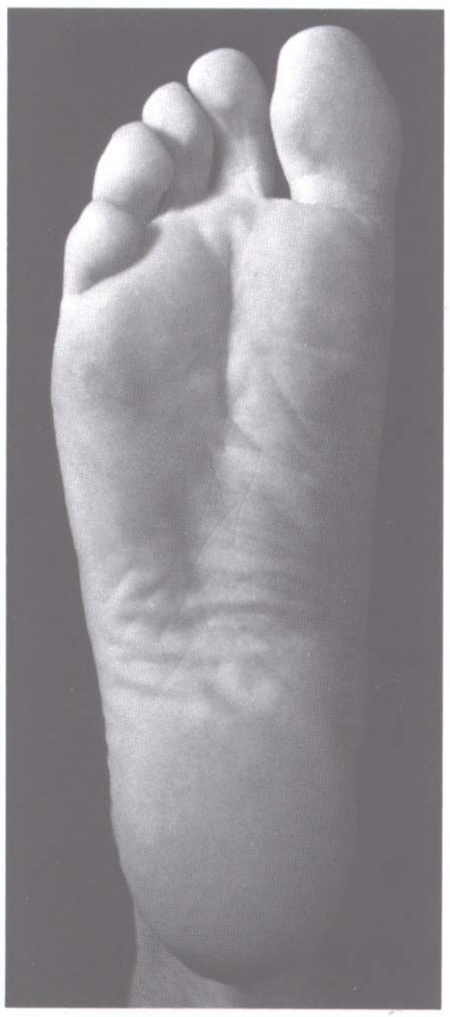




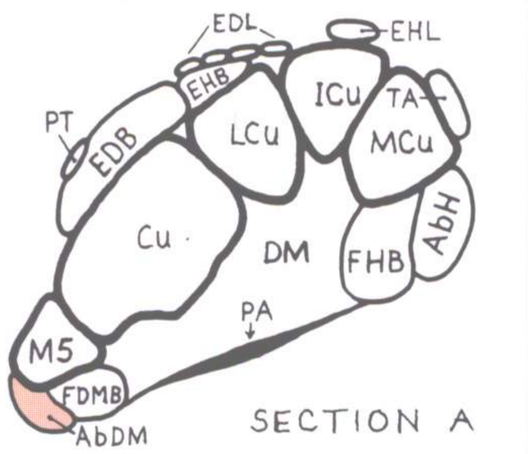


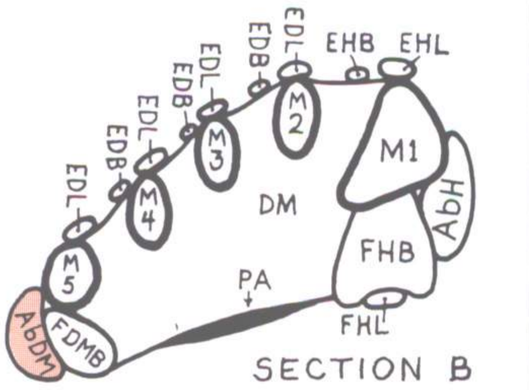






AbDM *Abductor digiti minimi* **EDB** *Extensor digitorum brevis* **EDL** *Extensor digitorum longus*
FDL *Flexor digitorum longus* **FDMB** *Flexor digiti minimi brevis* **LM** *Lateral malleolus* **M** *Metatarsal*
PA *Plántar aponeurosis* **PB** *Peroneus brevis* **PL** *Peroneus longus* **PT** *Peroneus tertius*





Abductor Digit Minimi

ORIGIN Both the medial and lateral processes and the intervening bone between these areas, on the bottom of the calcaneus, and from the plantar aponeurosis.

INSERTION Lateral aspect of the base of the proximal phalanx of the little toe.

ACTION Abducts and assists in flexing the little toe.

STRUCTURE This muscle lies under the lateral border of the foot. In side view, it appears to have two bellies, one anterior and one posterior to the expanded base of the fifth metatarsal bone. Its tendon develops on the deep (superior) aspect of the belly before reaching the level of the base of the fifth metatarsal, but its fleshy fibers usually continue anteriorly up to the head of the fifth metatarsal. At the midpoint of the foot, the tendon glides over the smooth undersurface of the expanded base of the fifth metatarsal.

Passing anteriorly from the origin of the abductor digiti minimi, some fibers insert into the base of the fifth metatarsal, while some new fibers take origin from it.

This muscle is for the most part concealed by the dense, fibrous fat pad of the sole of the foot. However, the anterior portion of the belly located between the base of the fifth metatarsal and the metatarsophalangeal joint can occasionally be seen on the surface lying lateral to the shaft of the fifth metatarsal. Its form is very subtle. The posterior portion is concealed by the plantar fat.

The *EYE* consists of the eyeball and upper and lower eyelids. It is surrounded by the bony orbit.

The **eyeball** is basically a sphere. The convex, flattened, domelike **cornea** sits on its anterior surface. Because it is transparent, the cornea is not easily seen when the eye is open, but when covered by the eyelid, its subtle form become apparent, especially when the eyeball moves. The **sclera** is the white of the eye. It may have a tinge of blue or yellowish color. Because the eyeball is wet and its surface glossy, a highlight may develop on the surface of the sclera and/or cornea.

The **iris** is the colored ring that is seen through the cornea. It functions as an aperture, dilating and constricting to control the amount of light entering the eye through the round opening of the **pupil.** The pupil is located in the center of the iris. It appears as a black dot, becoming larger in low-light situations, letting more light in, and constricting to almost a point under strong light. The color of the iris may be varying shades of light to dark brown or black, blue, blue/green, or gray. The lens is located just behind the iris.

The eyeball sits within the bony eye socket. It is surrounded by a cushion of fat that fills the space between the eyeball and skull. Its size varies little between individuals; the apparent size of the eye is determined by the opening between the eyelids.

The upper and lower **eyelids** consist of the thin palpebral portion of the orbicularis oculi muscle lying over the semirigid, curved **tarsal plate** which is embedded in each eyelid. The upper eyelid is larger and slightly longer (wider) than the lower. The edges of the eyelids contain the **eyelashes,** arranged in double or triple rows. The upper lashes are longer and more densely packed than the lower ones. They curve upward, while the lower lashes curve downward. When the eyes are closed, the lashes do not intertwine. The lashes begin a short distance from the inner corner of the eye and end at the outer corner.

The **caruncula lacrimalis** is the small pink protuberance located at the inner corner of the eye in the angle where the upper and lower eyelids meet. The **plica semilunaris** ("third eyelid") is a small, thin membranous fold sitting on the surface of the eyeball just lateral to the caruncula. Its edge curves medially.

The eyelids, whether opened or closed, lie on the spherical form of the eyeball. Because the eyelids have a thickness, the **edges of the eyelids** can be seen as very narrow, elongated planes lying perpendicular to the surface of the eyeball. The edge of the upper eyelid is a "down" plane and is therefore usually darker, while the edge of the lower eyelid is an "up" plane and lighter. Because the upper eyelid descends almost halfway down the front of the sphere of the eyeball (near its equator), its edge plane is barely seen when looked at head on, whereas the narrow edge plane of the lower eyelid is easily seen because it sits lower on the surface of the eyeball and is directed upward and forward. The lashes are located at the edge of the eyelid where the front planes of the eyelids meet their narrow edge planes. This edge is thickened on the upper eyelid and may also be thickened into a slight ridge on the lower eyelid.

When opening and closing the eye, the upper eyelid rises and descends. The lower eyelid moves only minimally. When the upper eyelid is raised, most of it disappears under the skin fold above it, leaving only its edge (and lashes) visible. In the relaxed position of the open eye (when looking straight ahead), the lower eyelid just touches the bottom of the iris, while the upper eyelid overlaps its upper border just slightly. Opening the eyelids or closing them slightly from this neutral open position can create various strong facial expressions. When the open eyes look upward, the upper eyelid rises higher than its normal position, while the lower eyelid stays close to its original position, exposing more of the white sclera below the iris. When the open eyes look downward, both upper and lower eyelids descend, and the lower border of the iris rolls under the edge of the lower eyelid.

When the eyelids are opened, they form an ellipitical opening that is pointed at its inner and outer ends. In the open eye, the edge of the upper eyelid has a greater curvature than the edge of the lower eyelid (which is straighter). The axis through the points of greatest curvature of the edges of the upper and lower eyelids passes downward and laterally (the high point of the edge of the upper eyelid is located medial to the midline of the eyeball; the change in curvature of the lower eyelid lies lateral to the midline). However, as the eyeball is rotated side to side, the cornea pulls the high point of the upper eyelid with it. When the eyelids are closed, a slit forms where they meet, at the level of the bottom of the iris (below the equator of the eyeball). This slit is a downwardly curved line whose very inner end changes direction to point downward.

The **corners of the eye** are located where the medial and lateral ends of the upper and lower eyelids meet. The junction at the inner corner (medial canthus) has a wider angle than the outer corner (lateral canthus). The outer corner rests on the eyeball; the inner corner does not—it is displaced medially onto the side of the nose. At the outer corner, the upper eyelid may

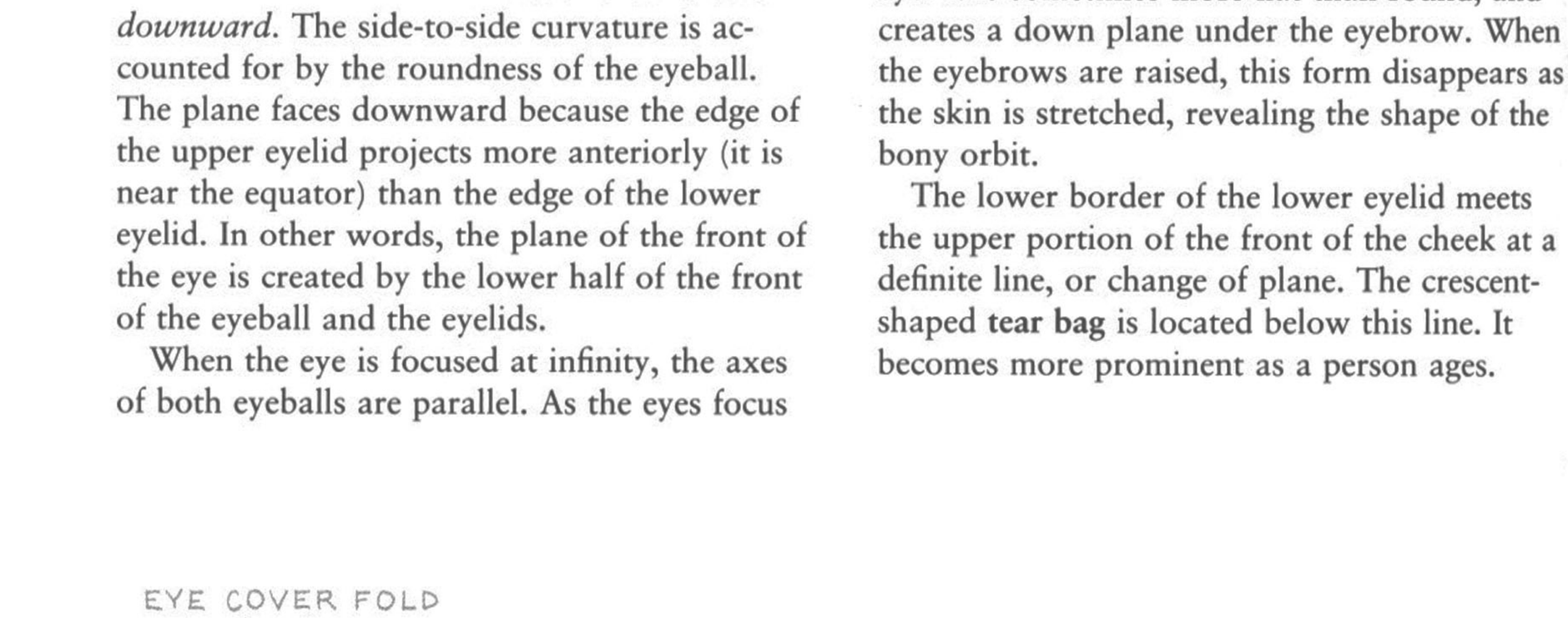
overhang the lower eyelid slightly. The inner and outer corners usually lie on a horizontal line or else the outer corner sits at a level slightly higher than the inner corner. The inner corner is located more anteriorly, while the outer corner sits more posteriorly toward the *side* of the eyeball; the axis through the corners of the eye therefore passes laterally and posteriorly. A depression is located above the inner corner of the eye.

The front surface of the open eye (eyeball and lids) can be simplified into a plane that is curved side to side and directed forward and *downward*. The side-to-side curvature is accounted for by the roundness of the eyeball. The plane faces downward because the edge of the upper eyelid projects more anteriorly (it is near the equator) than the edge of the lower eyelid. In other words, the plane of the front of the eye is created by the lower half of the front of the eyeball and the eyelids.

When the eye is focused at infinity, the axes of both eyeballs are parallel. As the eyes focus on nearer and nearer objects, the axes converge, ultimately assuming a cross-eyed position at their greatest convergence. The axes never diverge (become "wall-eyed") in normal eyes.

The **eye cover fold** is the skin flap below the lateral portion of the eyebrow and above the lateral portion of the upper eyelid. It is seen as a bulging, oblique skin form (somewhat teardrop-shaped) when the eye is in the normal open position. It conceals the upper and outer edges of the bony orbit. Laterally, the wide end of this form ends past the outer corner of the eye. It is sometimes more flat than round, and creates a down plane under the eyebrow. When the eyebrows are raised, this form disappears as the skin is stretched, revealing the shape of the bony orbit.

The lower border of the lower eyelid meets the upper portion of the front of the cheek at a definite line, or change of plane. The crescent-shaped **tear bag** is located below this line. It becomes more prominent as a person ages.



Nose

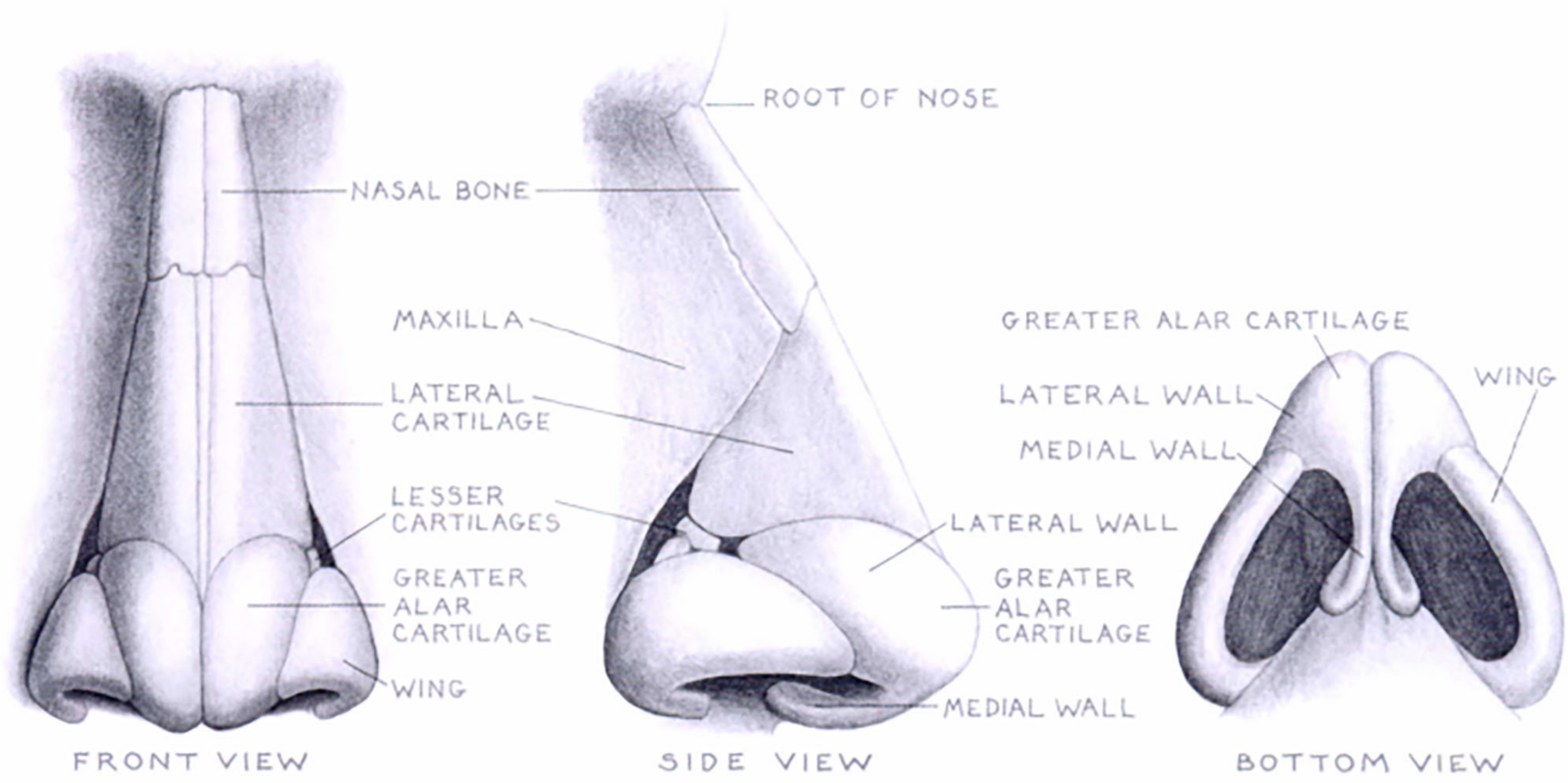
The *NOSE* is made up of bone, cartilage, and fatty tissue. It is pyramidal in shape, consisting of a long narrow plane on its front edge, two inclined side planes, and a triangular bottom plane.

The **bridge of the nose** is formed by the two nasal bones. The junction of these bones with the frontal bone at the **nasion** is called the **root of the nose.** The middle section of the nose is made up of the flat, paired **lateral cartilages** (upper cartilages), each triangular in shape. The junction on the front edge of the nose between the nasal bones and lateral cartilages is the widest part of the bridge. In side view, the nasal bones meet the lateral cartilages at an angle, forming the "bump" of the nose. The maxilla bone, located posterior to the nasal bone and nasal cartilages, contributes to the formation of the side plane of the nose.

The **tip** or **apex** of the nose is made up of the paired **greater alar cartilages** (lower or tip cartilages). Each greater alar cartilage is somewhat U-shaped, but is better visualized as having a larger, flattened, ovoid portion, the **lateral wall** (lateral crus), and an inferior extension or tail, the **medial wall** (medial crus). The lateral wall forms the tip of the nose and then extends to the side of the nose between the lateral cartilage and wing of the nose. The greater alar cartilages may inconspicuously blend into the rest of the nose, or they may be clearly defined all around and separated by a vertical groove or notch where the two meet in front. They also range from being rounded to exceedingly pointed at the tip of the nose (a short distance on either side of the midline). The bottom of the ovoid lateral wall may develop a distinct, narrow, sharp plane. The medial wall forms the **movable nasal septum,** located at the midline on the bottom of the nose between the nostrils. This septum is visible from the side view because it descends lower than the wing of the nose. The *plane* of the opening of each nostril is therefore directed downward and slightly outward, permitting the opening of the nostril to be seen partially from the side view. From below, the entire greater alar cartilage (both lateral and medial walls) is seen bordering the anterior half of the nostril.

Two to four **lesser alar cartilages** (small, or sesamoid, cartilages) are found on each side of the nose at the posterior end of the lateral wall of the greater alar cartilage. They are not seen in life. The rounded **wing of the nose,** or **alae nasi,** made up of dense, fibrous, fatty connective tissue, surrounds the **nostrils,** or **nares.** These oval apertures taper anteriorly and are directed anteriorly and medially when seen from below. The rigid, vertical **septal cartilage** lies inconspicuously between the paired cartilages, on the midline of the nose. It does not participate in the formation of the movable nasal septum.

The nasal bones are completely rigid, the lateral cartilages semirigid, the greater alar cartilages slightly flexible, and the fatty wings soft and flexible. The nose is therefore harder and strongly attached superiorly and softer and more movable inferiorly.



Mouth

The *MOUTH* consists of the muscular, highly movable upper and lower **lips,** or **labia.** The mouth region includes more than just the red portion of the lips; it technically extends from the base of the nose down to the fleshy prominance of the chin (to the mentolabial sulcus). The red color of the lips is caused by blood capillaries lying close to the surface. The lips are normally dry. They curve around the cylinder of the teeth.

The **upper lip** is made up of three forms: a small rounded form located on the midline, the **tubercle,** and two elongated forms on either side. The upper lip is flatter overall (more planar) than the lower lip, and because it is a "down" plane, it usually appears darker. Its upper edge forms a continuous, upwardly curving arch, interrupted in the middle by a wide V- or U-shaped notch where the base of the philtrum meets the tubercle. The tubercle is nonmuscular, whereas the rest of the lips is made up of the orbicularis oris muscle. The edge of the upper lip where the red part meets the skin may develop into a ridge, and a narrow top plane may develop across the upper surface of this ridge. Because this top plane may catch direct light rays, it is often conspicuous.

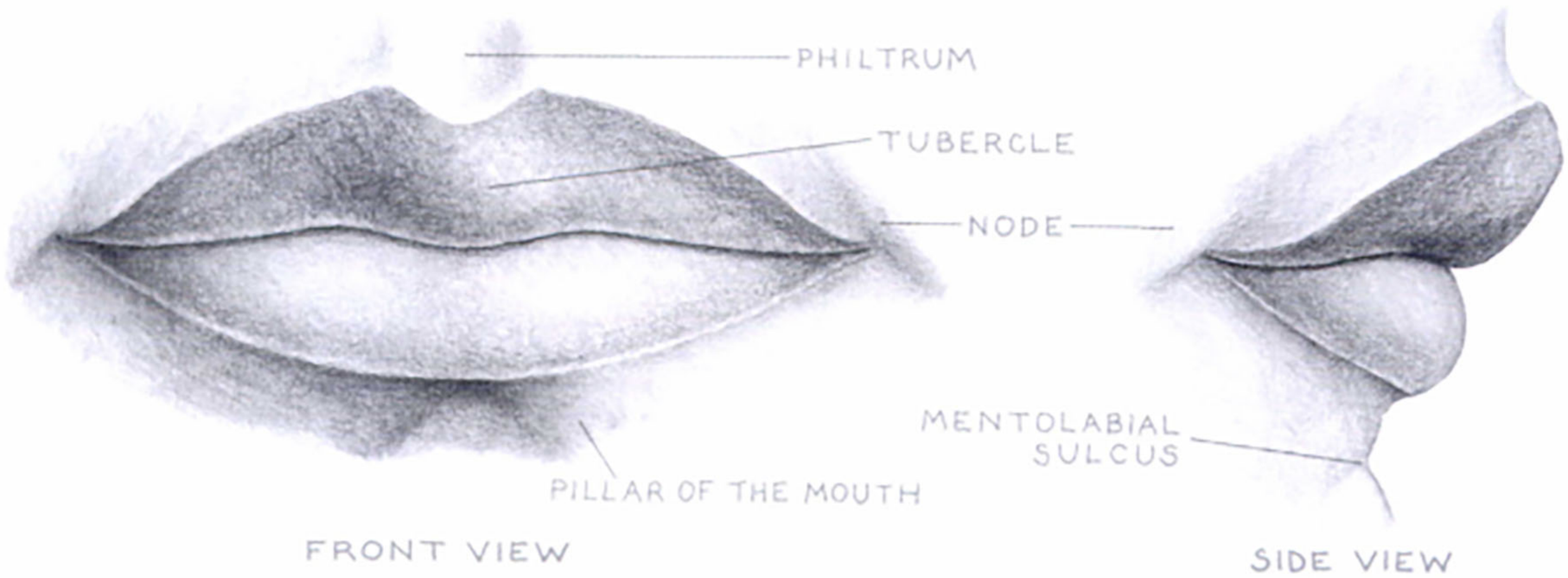
The **nasolabial furrow** or **sulcus,** passing downward and outward from the top of the wing of the nose to the outside of the angle of the mouth, technically delineates the upper lip region from the cheek. The vertical, wide, median furrow or depression located between the upper lip and base of the nose is called the **philtrum.** It is bordered by a vertical ridge on either side. The oblique, oval muscular form located immediately lateral to the angle of the mouth is called the **node** or **modiolus** (see Facial Muscles).

The **lower lip** is made up of two elongated, horizontal forms that meet at the midline. It is heavier and fuller than the upper lip, and its lower edge is more squared-off. It has a raised edge along its border where the red part meets the skin. This border may not appear at the middle of the lower lip, but it does develop laterally. It is especially prominent at the angle of the mouth, where there is a strong separation between this ridge and the large form of the red part of the lower lip. The surface of the lower lip may be continuous with the skin below (no edge), and the lip proper is distinguished by color change alone. Averaged out, the red part of the lower lip is an "up" plane, and usually receives direct light, making it appear lighter than the upper lip.

The lower lip region is separated from the chin by the horizontal **mentolabial sulcus.** Columnar forms passing downward and outward from below each half of the red part of the lower lip are referred to as the **pillars of the mouth.**

When the mouth is closed, the forms of both lips touch at the **mouth line,** with the convexities of one lip lodging in the hollows of the other. The mouth line is therefore multiply curved—from the midline outward, this line inclines upward for a short distance, downward for a longer distance, and then upward again for a very short distance. It lies at the level of the *middle* of the upper front teeth.

In the front view, the angle of the mouth approximately aligns with a line dropped from the pupil of the eye. In side view, the angle aligns with a line dropped from the front of the eyeball.



Ear

The external *EAR* consists of the auricle and external auditory meatus. The **auricle,** or **pinna** (the outer ear proper), is a complex, ovoid, cartilaginous funnel, larger above, that directs sound into the **ear hole,** or **external auditory (acoustic) meatus.** The auricle is made up of a single complex cartilage, as well as fatty skin.

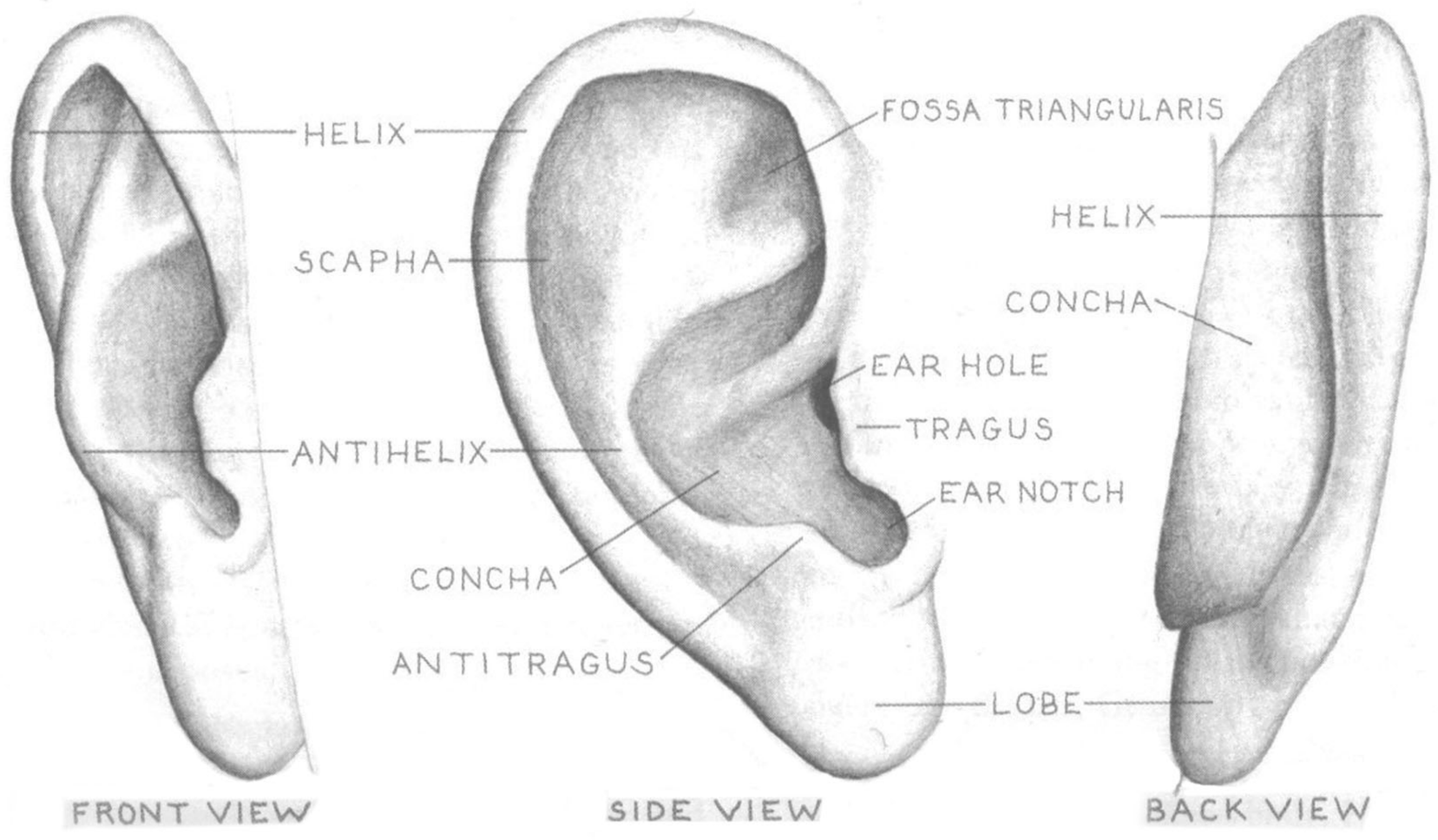
The **concha** is the deep, bowl-shaped part of the cartilage that attaches directly to the side of the head at the front of the mastoid process of the skull. The ear hole is located in the lower front corner of the concha. The **helix** rings the uppermost portion of the ear. It begins deep on the floor of the concha as the **crus of the helix,** dividing the concha into a smaller upper portion and a larger lower one. It passes forward, outward, and upward and then curves down the posterior edge of the ear, to finally end when it reaches (blends into) the earlobe. For the most part, the helix is cartilaginous, but its lower back portion is formed by skin. Its inner edge on the upper half of the ear is sharp. An anteriorly pointing **tubercle** is often seen on the inner edge of the upper back corner of the helix.

The **antihelix** roughly parallels the helix, lying internal to it. It also borders the back and top of the concha. It splits superiorly (anteriorly) into a U-shaped fork having a rounded and large upper leg and a narrow and sharp lower leg. The legs are separated by a depression called the **fossa triangularis.** The antihelix ends inferiorly just before reaching the earlobe and antitragus. The elongated, curving furrow between the helix and antihelix is the **scapha.**

The oblique **ear notch,** or **intertragic notch,** is located on the front edge of the ear just above the earlobe. It is bordered by cartilage. The **tragus** is a double-pointed cartilaginous projection located above the ear notch. It lies just posterior to the condyle of the mandible at the posterior end of the zygomatic arch. The **antitragus**—projecting opposite the tragus—is located above the lobe. The tragus and antitragus partially project over the openings of the concha and ear hole. The tragus is separated from the helix by a notch. The **earlobe,** or **lobule,** is a softy, fatty skin form that hangs off the bottom of the ear. It is usually independent of the side of the jaw, but is sometimes attached.

From the front view, the ear is widest at the top (at the helix). The antihelix projects laterally at its midpoint, receding inward toward the head both superiorly and inferiorly. From the side view, the ear appears oblique, its long axis directed downward and forward. This axis, as well as the front edge of the ear, is roughly parallel to both the back of the ramus of the lower jaw and the profile of the nose. From the back view, the outer edge of the helix makes an S curve, while the bowl-shaped concha attaches to the side of the head. The concavities seen in the side (outer) view of the ear become convexities on the cranial (medial) side.

The top of the ear is approximately in line with the brow, while the bottom of the lobe usually coincides with the level of the base of the nose. These alignments do vary quite a bit, though. The straight front edge of the ear is located approximately midway between the front and back of the head; the ear hole is located just posterior to the midline. The auricle of the ear sits on the side of the base of the cranium. The overall plane of the ear is directed outward, slightly forward, and slightly downward.



Fat

The *FAT LAYER,* or **panniculus adiposus,** is made up of **adipose tissue,** which in turn is made up of **fat cells.** The fat is located in the superficial fascia between the skin and muscles, and to a varying degree influences the external form of all figures, regardless of how thin they are. Although capable of forming a general blanketing layer over the body which can conceal and smooth over the superficial anatomy—commonly in women and children—it can also be almost entirely lacking, revealing every nuance of muscle striation and bony landmark in the well-defined or "thin-skinned" individual. It is the lack of fat, not the degree of muscularity, that determines a person's surface definition.

The thickness of the panniculus adiposus varies in different areas of the body. There is more fat on the trunk than on the limbs. In general, the female has a greater percentage of adipose tissue.

For the sake of clarity in producing well-conceived figures, it is best to think in terms of separate, distinct **fat pads** which have their own definable forms. Because the fat pads gradually blend into each other or into the surrounding muscles—simplifying the volumes and rounding off the figure—they can be difficult to isolate and differentiate.

Fat is often not present on or near some of the bony landmarks, making them prominent and projecting (anterior superior iliac spine, medial epicondyle of the humerus). When surrounded but not covered by fat, other bony landmarks may produce dimples, especially in the female (posterior superior iliac spine).

The shape of the female figure is formed in great part by the classical female fat pads. They are most prominently developed on the outer back corner of the pelvic region: hips (iliac crest), gluteal muscles, and upper thigh. The width of the female pelvic region is created mostly by the greater width of the pelvic bones, which in turns places the greater trochanters further apart, and also by the relatively narrower rib cage. The two gluteal pads and the flank pad often fuse into a single form, giving the buttocks the appearance of reaching up to the waist ("high-waisted").

Besides forming fat pads, fat will accumulate in certain recessions in the body. It does not form distinct pads here but rather acts as **filler** (e.g., on the top of the shoulder behind the clavicle, in the armpit, and beneath the tendons at the wrist and ankle).

The following descriptions are of persons with classical figures, having minimal, yet typical fatty deposits.

HEAD The **cheek fat pad** is located on the front of the face, between the front edge of the masseter muscle and the side of the nose, and below the cheekbone. Its medial portion is called the **infraorbital triangle.** The upper boundary of the infraorbital triangle is defined by the infraorbital furrow, and its lower medial edge by the nasolabial furrow (see Facial Forms in the Facial Muscles section). As one ages, a distinct crescent-shaped fat pad or "bag" develops below the lower eyelid.

NECK ***Female only:*** Some accumulation of fat may develop in the pit of the neck (bottom of the front of the neck) as well as on the back of the neck, filling the tendinous depression of the trapezius that surrounds the spinous process of the seventh cervical vertebra.

ARM Fat is more abundant on the upper arm than on the forearm. It is also thicker on the back of the upper arm than on the front, especially superiorly in the female where the deltoid meets the triceps. When present, it forms a narrow blanketing layer, rather than a distinct fat pad.

The armpit is filled with fat, and the medial surface of the brachialis (between the biceps and triceps) is covered with a substantial amount of fat (to protect the nerves and blood vessels).

HAND The fat creates cushions on the palmar aspects of the metacarpophalangeal joints and forms the **finger pads,** which are present on the palmar aspects of all the individual phalanges. These pads are denser on the distal phalanges. Both the thenar and hypothenar eminences are covered by a layer of fat, especially toward the center of the palm (see Skin—Hand and Foot). If fat is present on the dorsum of the hand but absent on the knuckles (usually in the female), dimples may form over the metacarpophalangeal joints when the fingers are extended or hyperextended.

CHEST Fat fills the hollow above and behind the clavicle and below it in the infraclavicular fossa between the pectoralis major and deltoid.

Male: A crescent-shaped **pectoral fat pad** of varying size is located below and to the outside of the nipple; it can, to a greater or lesser degree, expand onto the surface of the lower half of the pectoralis major. It aids in squaring off the lower border of the pectoral form.

Female: The form of the **female breast** is for the most part fat, the mammary glands being small and embedded in the fat toward the center of the breast. The female breast is the most movable fat form of the body, changing shape considerably depending on the position of the figure (see Breasts, Genitals).

ABDOMEN ***Male:*** Fat is not present on the abdomen in the well-defined body. However,

the abdominal fat can reach astonishing dimensions as it is deposited both on top of and deep to the abdominal muscles, as well as accumulating around the intestines.

Female: The **abdominal fat pad** is located around and especially below the navel. It may begin to split into a separate pad on each side of the midline, mostly below the navel, but extending superiorly above it.

PUBIS The triangular **pubic fat pad,** or **mons pubis,** sits on top of (anterior to) the pubic symphysis in both the male and female; it is covered by the pubic hair. Larger in the female, it is referred to as the **mount of Venus** or **mons Veneris.** This fat pad creates a fatty bridge from thigh to thigh, continuing into the fat of the femoral triangle. Its upper edge is occasionally defined by a horizontal line. Its sides are strongly separated from the thighs by a deep fold called the line of the thigh. The front edges of the pubic bones, at the pubic symphysis, are covered by this fat pad.

FLANK ***Male:*** A cresent-shaped **flank fat pad** is almost always located on the lower back edge of the external oblique muscle, regardless of how thin the individual is. The external oblique, skin, and flank *fat pad* together produce the typical *flank form* on the side of the male torso below the waist. The fat pad always blends into the form of the external oblique. The oblique **iliac line** defines the bottom of the *flank form*. This line is formed by the lower edge of the external oblique anteriorly and by the inferior border of the flank fat pad posteriorly. Additional "filler fat" partially fills the depressed area between the erector spinae and the back of the flank form (the posterior edge of the flank form, produced by the flank fat pad, is distinct from this filler fat). This depression, known as the superior lumbar fossa, is created by the change in curvature of the iliac crest of the pelvis at the reentering angle. The filler fat extends downward for a short distance onto the surface of the gluteal muscles.

Female: The female **flank fat pad** is much larger than that of the male. It wraps around the side of the body, extending up to the waist, and downward just past the iliac crest. Its lower edge does not thin out, but remains thick as it merges into the thick lateral gluteal fat pad below. The meeting of the two pads may be either distinct or continuous—they form a thick layer that covers the posterior portion of the iliac crest and obliterates the posterior portion of the iliac line. When present, the furrow between the flank and lateral gluteal fat pads is the vestige of the sharp iliac line found in the male. As the flank fat pad curves around to the back of the flank, it is prolonged upward. Its posterior edge is usually sharply delineated where it meets the erector spinae, as is its upper edge at the waist. The anterior edge thins out and feathers into the surface of the external oblique. Posteriorly, this fat pad may extend over to the dimple of the posterior superior iliac spine of the pelvis, but it never covers it. The flank fat pad usually develops a complex, saddle-shaped surface as it curves around the side of the body, passing downward onto the iliac crest and upward onto the lower portion of the back of the rib cage.

HIP (upper lateral gluteal region) ***Female only:*** A well-developed fat pad, the **lateral gluteal fat pad,** forms on the outer surface of the gluteus medius. It meets and partially blends with the flank fat pad above and with the posterior gluteal fat pad below and to the back. Subtle furrows may be present where it meets these other pads, especially the posterior gluteal pad. It feathers out into the surface of the gluteus medius in front and approaches, but does not cover, the dimple of the posterior superior iliac spine in back. The lateral gluteal fat pad usually does not cover the subcutaneous greater trochanter of the femur.

BUTTOCKS ***Male:*** The **posterior gluteal fat pad** develops on the inferior border of the gluteus maximus (on the lower inner corner of the buttock where the vertical gluteal cleft meets the horizontal gluteal skin fold). This fat pad extends inferiorly onto the back of the thigh; however, in the straight standing leg, this lower **inferior gluteal fat extension** is separated from the upper posterior gluteal pad by a restricting band of fascia, the **gluteal band,** that cuts across the gluteal fat and forms the **gluteal skin fold.** In this position of the leg, the surface of the inferior gluteal fat extension develops an oblique plane that faces downward and backward. When the thigh is flexed at the hip joint, the gluteal fold disappears and the two portions of the gluteal fat pad flow together.

Female: The **posterior gluteal fat pad** is much thicker in the female than in the male, and it extends upward over the surface of the gluteus maximus. It is thickest in its lower region. The upper inner edge is clearly defined at the edge of the sacral triangle. This pad reaches up to but does not cover the posterior superior iliac spine. It passes around the side of the buttock where it feathers out just before reaching the greater trochanter. Its lateral edge usually blends into the outer thigh fat pad, while a faint furrow may be present where it meets the lateral gluteal fat pad.

The female **inferior gluteal fat extension** is located, as in the male, below the gluteal fold. This fold disappears when the thigh is flexed, and the posterior and inferior gluteal pads flow together. The inferior gluteal extension may be separate and distinct from the inner and outer

thigh fat pads, or it may blend with them (especially the outer thigh pad). In this case, it connects both thigh pads across the back of the thigh, creating a single complex form on the back and sides of the upper portion of the thigh.

THIGH ***Female:*** Fat is more abundant on the thigh than on the lower leg. It forms the **outer thigh fat pad,** located on the upper outer surface of the thigh, which sits on top of the vastus lateralis, inferior to the greater trochanter. This fat pad blends with the posterior gluteal fat pad above and curves around the back of the thigh, under the buttock, to blend with the inferior gluteal fat extension. The widest point of the female pelvic region, created by the outer thigh fat pad, is located just below the greater trochanter at the level of the gluteal fold. (The male is usually widest at the distal end of the belly of the tensor fascia lata.) Because of the extra fat on the thigh and its resultant increased width, the female thigh appears shorter than the male thigh.

Fat also accumulates on the upper half of the inside of the thigh in the female. This **inner thigh fat pad** tapers inferiorly and may reach all the way down to the inside of the knee, blending with the form of the vastus medialis. It blends with the outer thigh fat pad via the inferior gluteal extension on the top of the back of the thigh. Because of the absence of fat on the front of the thigh, it does not connect with the outer thigh fat pad across the front. It does, however, extend anteriorly for a short distance to cover the inner front corner of the thigh. The thickness and shape of the inner thigh fat pad determines the amount of space present between the very upper ends of the thighs in the female when the legs are held together.

An accumulation of fat is present on the front of the lower end of the thigh, just above the patella. This **lower anterior thigh fat pad** obscures the definition of the inferior ends of the bellies of the quadriceps muscles where they insert into the quadriceps tendon. This fat is present even in thin, well-defined women. The classical male figure does not develop the inner, outer, and lower anterior thigh fat pads.

Both sexes: The triangular area at the upper medial end of the front of the thigh—bordered by the inguinal ligament, iliopsoas, adductor longus, and sartorius—is filled with major nerves, arteries, and veins. These structures are cushioned and protected by an ample mass of fat, which lies on top of and completely conceals the pectineus muscle. This region is called the **femoral triangle.** In the standing position, this area bulges and is continuous with the surface of the thigh (not defined). When the leg is flexed and laterally rotated, the fat sinks in, forming a depression called the "hollow of the thigh."

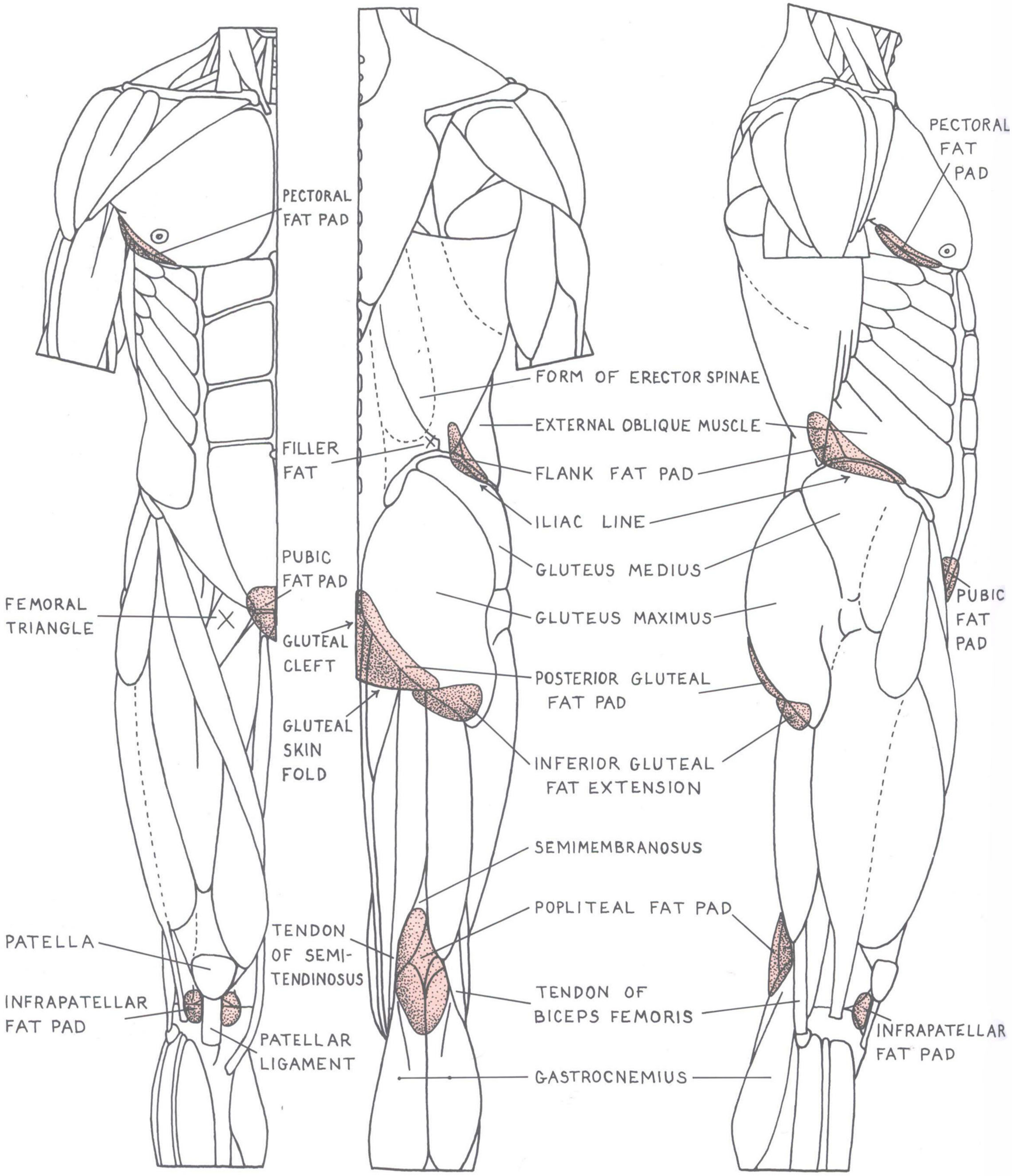
KNEE ***Front:*** There is a fat pad located inferior to the patella that lies deep to the patellar ligament. During full knee extension with the thigh muscles tensed, this **infrapatellar fat pad** is pushed forward, bulging out on either side of the taut patellar ligament. Along with the ligament, the fat pad creates a single heart-shaped form below the patella. The patellar ligament may be slightly depressed at the center of this form. Sometimes, instead of creating the heart-shaped form, the fat may distinctly bulge out on either side of the patellar ligament into a single rounded form on each side. These round forms are often confused with the upper corners of the patella: the superior set of two rounded forms is always the patella; the inferior set, the fat forms. When the thigh muscles are relaxed, the patella drops down, and irregular horizontal skin swellings develop across the surfaces of the inferior apex of the patella and the patellar ligament. When the knee is flexed, the infrapatellar fat pad disappears as it slides deep into the opened knee joint.

Back: On the back of the knee, the **popliteal fat pad** is situated in the empty diamond formed by the diverging inferior ends of the hamstrings and the diverging superior ends of the heads of the gastrocnemius. This fat pad bulges during knee extension into an elongated, vertical column, located slightly to the lateral side of the back of the knee. It is hard to the touch because it is pressed against the dense fascia which covers it. This longitudinal relief is often sharply bordered on either side by vertical furrows created by the tendon of the biceps femoris laterally and the tendon of the semitendinosus medially; however, the fat is thinner medially where its form lies on and blends with the bulging belly of the semimembranosus (just lateral to the tendon of the semitendinosus). These furrows are usually more pronounced in the female. The popliteal fat thins and feathers out onto the surfaces of the hamstring muscles superiorly and onto the muscular columns of the gastrocnemius inferiorly. The form of the popliteal fat disappears as the knee is flexed, creating a hollow on the back of the knee.

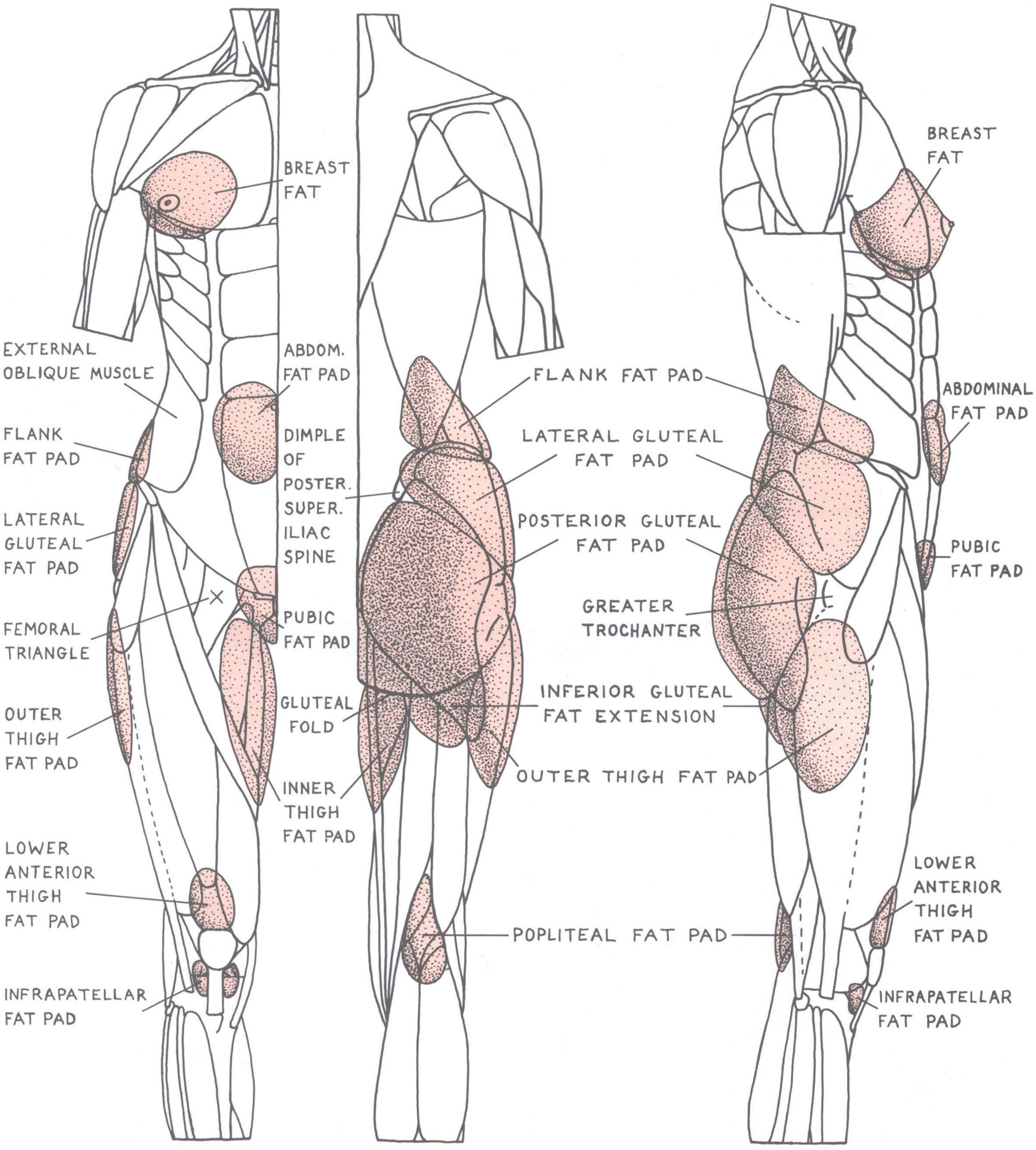
LOWER LEG Fat fills the gap between the Achilles tendon and bones of the ankle.

FOOT The fat forms thick, dense, elastic, fibrous cushions on the sole of the foot. They are most developed under the weight-bearing points of support, such as under the heel, the metatarsophalangeal joint of the big toe, the metatarsophalangeal joints of the third, fourth, and fifth toes, and the tips of the toes (see Skin—Hand and Foot).

Male Fat Pads

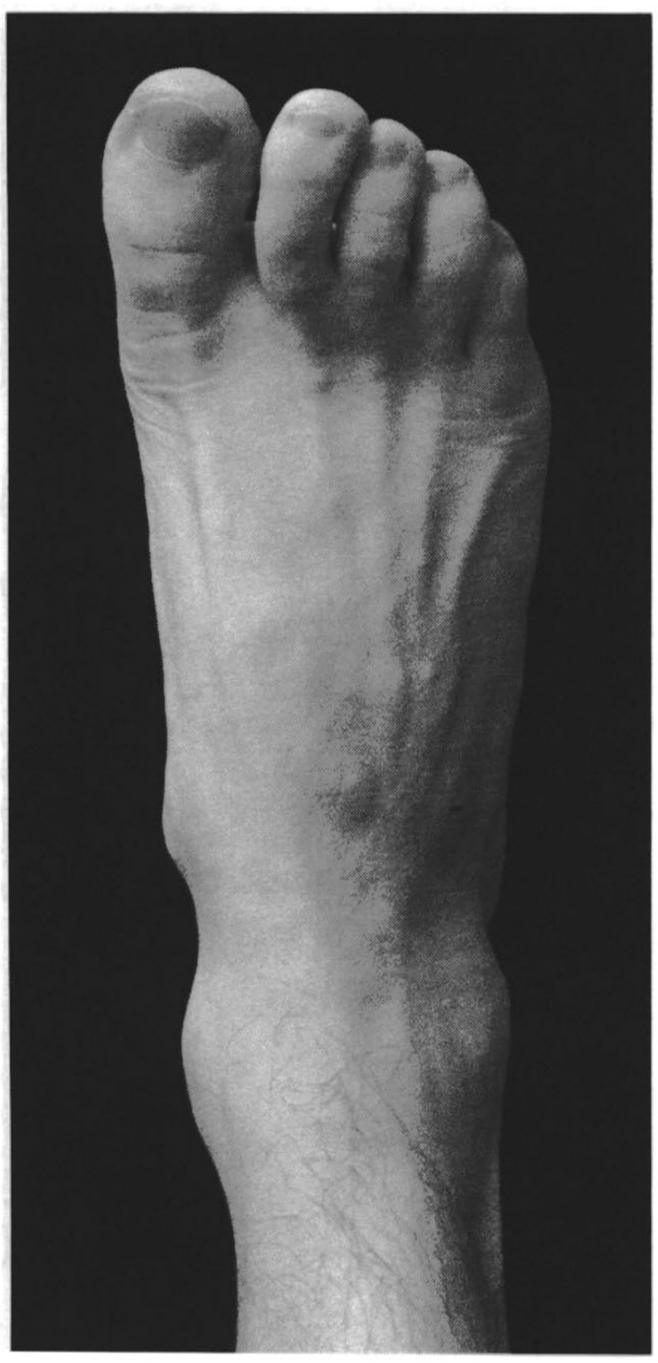


Female Fat Pads



Back of hand

Palm of hand



Top of foot

Sole of foot

Skin—Hand

The palm side of the hand is also referred to as the volar aspect, while the back of the hand is called the dorsal aspect. The volar aspects of the palm and fingers are padded with protective cushions of dense fat.

The **skin of the palm of the hand** continues distally past the metacarpophalangeal joints to end halfway down the proximal phalanges of the fingers; the palmar surface of the hand therefore appears longer than the dorsal surface, while the fingers appear longer when viewed from the back of the hand (the backs of the fingers correspond to the skeleton). The edge of the skin web between the thumb and index finger passes from the metacarpophalangeal joint of the thumb to that of the index finger. The skin between the fingers is referred to as the **webs of the fingers.** For palmar and dorsal skin wrinkles, see the following section on skin folds.

Except for the thumb, each finger has three fatty **finger pads** on its palmar aspect, one per phalanx, which act as protective cushions. The thumb has only one well-developed skin pad, located on its distal phalanx. Its proximal phalanx is covered with fatty skin which does not quite form a defined pad. The distal pads taper toward the fingertip, and their tips are rounded. These pads of the thumbs, the index fingers, and the little fingers have a greater taper and are somewhat triangular (in palmar view). The proximal and middle pads of fingers two through five are roughly equal in size; the distal pad is slightly longer than the other two. The distal pads of all five fingers are quite long relative to the short distal bony phalanges they cover; the pads extend past the ends of the phalanges in order to protect the tips of the bones.

The **fingernails** are modified skin structures. They are double curved and somewhat trapezoidal in outline. The longitudinal curve (seen in the side view) is straighter than the transverse curve (seen in the end view). The straight sides of each nail diverge distally. The proximal and distal borders curve in opposite directions. Distally, the flesh-colored part of the nail becomes unattached to the underlying skin, turning whitish at the free border. The fatty tips of the finger pads extend beyond this color change.

A flattened skin **cuticle** develops on top of the base of the nail, extending up the sides for a short distance. The base of the nail usually has a small, lighter, oval area (pointed at the sides), called the **lunula.**

The thumb nail is largest (and also the widest relative to its length). The nails of the index, middle, and ring fingers are about equal in size, and that of the little finger is the smallest. The middle finger is the longest finger, and therefore its nail extends the furthest.

Skin—Foot

The **skin of the sole of the foot** forms three large **fat pads** on the sole: an oval pad under the heel, a round pad under the metatarsophalangeal joint of the big toe, and a teardrop-shaped pad under the metatarsophalangeal joints of the lateral *three* toes, which extends posteriorly under the lateral edge of the foot. The big toe pad meets the pad of the lateral toes at the axis of the second toe. These pads form a tough cushion under the weight-bearing bones, which are the points of support of the body. The heel pad is the thickest and its skin the toughest. Because of the thickness of the plantar fat, usually no muscles are seen on the sole. The plantar fat pads cover the metatarsophalangeal joints, causing the toes to appear shorter when viewed from the plantar aspect of the foot (as in the fingers).

The plantar aspects of the tips of the toes end in relatively large, round pads. Progressing laterally, the tip of each toe becomes more pointed. The pad of the big toe is much larger and is triangular. Looking at the bottom of the foot, the toes have only one large pad per toe, unlike the hand. When the toes are flexed, the toe pads approach and may touch the rest of the sole. It is only after the toes have been extended that a small area of the plantar aspects of the proximal and middle phalanges becomes visible.

The medial part of the middle section of the sole, where the skin is very delicate, does not make contact with the ground. This is easily observed in a footprint. This hollow of the sole is the medial arch of the foot. The dense **plantar aponeurosis** covers the muscles of the sole of the foot. The portion stretching between the heel and ball of the big toe becomes visible as a ridge when the big toe is actively or passively extended (such as during walking). It is located inferior and lateral to the form of the abductor hallucis. The plantar aponeurosis helps maintain the longitudinal arch of the foot.

The **toenails** have basically the same shape as the fingernails. As to the length of the toes, either the big toe or the second toe is longest (classically, the second toe is longest).

On the top or **dorsal side of the foot,** the relatively wide cleft between the big and second toes extends more posteriorly than does the cleft between the second and third toes. The posterior ends of the lateral three clefts end on a line that curves laterally and posteriorly.

Skin Folds

Numerous *SKIN FOLDS* (flexion folds or wrinkles) occur on the body, usually developing perpendicular to the directon of the muscle fibers or tendons located directly beneath them. This is true for the facial as well as for the skeletal muscles. To a greater or lesser degree, the skin, or **integument,** is rather loosely attached to the underlying structures, allowing it to slide over the muscles and subcutaneous bony areas. When two articulating body parts are brought closer together, the skin gathers into ridges and wrinkles at the flexion side of their junction, usually at or near the joints. The folds disappear when the parts are straightened out, but sometimes faint creases will persist. Skin folds appear as dark lines, and therefore indicate the contour of the form they lie on, which is especially useful in foreshortened views; they also define the ends of the various body units. In some skin folds, the deep aspect of the skin is attached to the underlying deep fascia by tough fibrous strands. This provides for consistency in location of certain folds in all individuals and greater efficiency in gathering the skin out of the way. Other wrinkles form arbitrarily as the skin is gathered.

HEAD Skin wrinkles on the face are found radiating from the outer corner of the eye (crow's-feet), across the forehead, vertically between the brows, and below the eye when the cheek is raised. The nasolabial furrow, passing from the outside of the wing of the nose downward and outward past the angle of the mouth, deepens into a skin fold when this furrow is raised by facial muscles. As a person ages, wrinkles remain after a muscle has been relaxed.

NECK Two horizontal skin folds typically appear on the front of the female neck: one just below the tip of the thyroid cartilage, and the other a short distance below it. In both sexes, deep skin wrinkles and thick ridges develop on the back of the neck when it is extended. When the head and neck are rotated to one side, skin folds develop on that side of the neck, toward the back. When the head and neck are tipped laterally, a major skin fold forms around the base of the neck, clearly defining the junction of the cylinder of the neck with the top of the trunk.

SHOULDER When the arm is raised straight up, a skin fold develops on the *top* of the acromion of the scapula where the fibers of the deltoid originate. When the arm is hanging down alongside the torso, an oblique fold forms at the back of the shoulder where the arm meets the trunk (at the back of the armpit). It passes upward and outward from the armpit, crossing the superior portion of the long head of the triceps and stopping when it reaches the deltoid. Excess skin bulges medial to the fold. Because of this fold, the back of the torso appears wider than the front.

On the front of the armpit, usually two or more skin folds are found on the anterior surface of the pectoralis major where the muscle passes from the chest to the arm (the intersection of the arm with the trunk). The folds converge inferiorly into the armpit and are present only when the arm is down by the side of the body.

BREAST As the female breast enlarges, or descends with age, a skin fold develops at its inferior border where the form of the breast lies on the rib cage.

TRUNK When the trunk is laterally flexed, one or more folds develop at the side of the waist (where the external oblique flank form meets the rib cage and/or at the bottom of the serratus anterior). During this same action, the iliac line (the lower edge of the flank pad) deepens as it descends over the surface of the gluteus medius.

ABDOMEN A deep skin fold forms across the front of the abdomen, slightly above the level of the navel (usually at the tendinous intersection), when the trunk is flexed forward. It passes laterally to the waist on each side. The belly bulges below this line. Other skin folds also develop above and below this primary skin fold.

GROIN There are several skin folds on the front of the pelvic area. They connect with each other in different ways, varying among individuals. In the male, the inguinal ligament is dominant; in the female, the line of the thigh is dominant. In the female, except for the line of the thigh, the skin folds are generally faint.

The line of the **inguinal ligament** is directly created by the lower edge of the aponeurosis of the external oblique. It curves downward and medially from the anterior superior iliac spine to the pubic tubecle. It varies in its degree of curvature, sometimes being almost straight, and deepens as the thigh is flexed. When evident in the female, the inguinal ligaments of both sides form a wider V than in the male because of the greater width and lower height of the female pelvis.

The **line of the thigh,** or **genital fold,** is located where the inner front corner of the top of the thigh meets the torso at the groin. It curves

upward and laterally from the genitals, passing along the side of the pubic fat pad. Its length varies from just defining the limit of the base of the genitals to reaching across most of the front of the thigh. The line of the thigh deepens and extends further laterally as the thigh is flexed.

The **lower abdominal line** passes across the upper part of the pubis at the midline of the body. It may be short, connecting the two inguinal ligaments, or may cross and continue past them, ending a short distance below the anterior superior iliac spine. This line defines the lower limit of the abdomen at the bottom of the belly; it may be partially covered by the pubic hair. When the inguinal ligaments are connected by the lower abdominal line, the classical single, wide, U-shaped curve, passing between the anterior superior iliac spines of each side of the body, is produced.

When the thigh is fully flexed, two skin folds appear at the anterior superior iliac spine. They are the lateral extensions of the inguinal ligament above and the line of the thigh below. These two lines intersect medially in this position.

BUTTOCKS In the straight, standing, weight-bearing leg, the **gluteal fold** shows up as a sharp, deep, horizontal skin fold that curves around the top of the thigh, passing from the inside around to the back. Its center has a downward curvature. It is caused by a band of dense fascia, the **gluteal band,** which crosses over the surface of the gluteus maximus and the posterior gluteal fat pad. The medial end of the gluteal fold, just below the buttock, is more pronounced because the fascia of the gluteal band attaches quite deeply into the ischial tuberosity of the pelvis. This fold becomes shallower laterally as the fibers of the gluteus maximus accumulate beneath it. As the thigh is flexed at the hip joint, the entire gluteal fold gets shallower, passes downward and outward, and eventually disappears (the form of the gluteus maximus and its fat pad still remain separate from the form of the upper medial end of the thigh). More than one gluteal fold may be present, but one will be more pronounced.

ELBOW During flexion of the elbow joint, two or more long skin folds cross the front of the elbow joint, passing over the tendon of the biceps. The more prominent distal fold passes from the medial epicondyle to the lateral epicondyle, but does not quite reach either of these bony landmarks.

When the elbow joint is extended, loose, wrinkled skin gathers just above the olecranon in back, on the surface of the tendon of the triceps. A soft skin bump forms directly on the olecranon itself.

WRIST Usually three flexion wrinkles develop on the palmar side of the flexed wrist. The most distal crease, at the base of the hand, is the most pronounced. In the extended wrist, several wrinkles appear on its back, with thickened, raised skin ridges between the folds. If the fingers are then extended, the distal skin ridges on the back of the wrist increase in size. Ulnar deviation of the hand at the wrist causes skin folds to form on the outside of the surface of the hypothenar eminence and on the outside of the wrist joint. Some faint wrinkles develop on the radial side of the wrist during radial deviation.

HAND The hand is well endowed with creases on the palm and flexor aspects of the fingers. The **palm** contains four major wrinkles, two principal and two accessory. The principal wrinkles are the **line of the thumb** and **line of the fingers.** The line of the thumb circles the thenar eminence. It is deepened during flexion and adduction of the thumb. The line of the fingers, or the distal transverse furrow, is located just proximal to the heads of the metacarpals. It passes across the palm from the index finger to the ulnar side of the hand and markedly deepens when the fingers are flexed. (The line of the fingers is not the line where the fingers meet the palm.)

The accessory wrinkles are the **longitudinal line** and **oblique line.** The longitudinal line begins near the wrist on the hypothenar eminence or between the thenar and hypothenar eminences, passes down the center of the palm, and ends at the base of the middle finger (or slightly toward the index finger). The oblique line begins at the middle of the hypothenar eminence, passes across the center of the palm, and ends between the thumb and index finger, where it intersects with the line of the thumb. Viewed together, these four major palm wrinkles form an M—the bottom of the M rests on the hypothenar eminence, while the top sits near the heads of the metacarpals of the index and middle fingers.

A double skin fold usually appears at the bases of the middle and ring fingers where they meet the palm, while a single fold appears at the bases of the index and little fingers. These folds lie at the middle of the proximal phalanx. Two folds appear at the proximal interphalangeal joints of fingers two through five, while the distal interphalangeal joints have one fold (the distal folds lie just proximal to that joint). The flexor side of the thumb has a deep fold where

it meets the thenar eminence (at the metacarpophalangeal joint), a few wrinkles at the middle of the proximal phalanx, and a regular, more pronounced wrinkle at the interphalangeal joint.

On the back of the hand, when fingers two through five are held together, skin folds appear on the sides of the bases of the fingers. The folds on each side of the base of the middle finger diverge toward opposite edges of the hand, while the fold between the ring and little finger heads toward the ulnar edge of the hand. These slightly oblique folds are created by the **second** and **third dorsal interosseous muscles** inserting into the radial and ulnar sides respectively of the base of the middle finger and the **fourth dorsal interosseous muscle** inserting into the ulnar side of the base of the ring finger. When the thumb is adducted, a deep fold develops between the head of its metacarpal and the first dorsal interosseous muscle.

When the fingers are extended, the back of the interphalangeal joint of the thumb and the backs of the proximal interphalangeal joints of the other four fingers develop an oval raised relief that contains several parallel, transverse wrinkles. These reliefs are somewhat flattened, and their centers may be slightly depressed. The reliefs disappear and the wrinkles become very faint when the fingers are flexed, revealing the underlying bony structures of the knuckles. The backs of the distal interphalangeal joints of fingers two through five may show faint transverse wrinkles when they are extended.

KNEE The transverse **popliteal fold** is located on the back of the knee. It roughly marks the inferior extent of the popliteal fat and is situated at the level of the interplane of the knee joint. It has an upwardly convex curvature and is directed obliquely downward and medially. Appearing faintly in the extended knee, it does not deepen until the knee has been flexed to 90° (a second fold may develop immediately above it). When the knee joint finally reaches full flexion, this fold reaches the head of the fibula laterally, but stops short of reaching the interplane of the knee joint on the medial side of the knee.

Two vertical furrows appear on the back of the extended knee on either side of the popliteal fat. They are not skin folds, but rather furrows created by the hamstring tendons. The transverse popliteal fold either terminates at these furrows or continues slightly past them, especially past the medial furrow. These furrows and the horizontal skin fold are more prominent in the female.

On the front of the extended knee, an oblique skin fold appears where the muscular belly of the vastus medialis meets the upper inner corner of the patella. It is more pronounced when the quadriceps is tensed.

ANKLE Several skin folds develop on the back of the Achilles tendon during plantar flexion of the foot, after the Achilles tendon loses its tension. This occurs as the knee is flexed and the foot is plantar flexed.

FOOT When the toes are flexed, numerous slightly raised, transverse skin ridges form across the sole of the foot, and a short longitudinal fold develops between the fat pads of the big toe and the other toes (this fold lies on the axis of the second toe). The junction of the toes with the sole is marked by very deep skin folds located at the middle of the proximal phalanges. There are only traces of a second distal flexion fold on each of the three middle toes.

Hair

The hair (head, pubis, beard) should be visualized first as a generalized single form, which is in turn made up of numerous individual clumps of hair that create a pattern of smaller convex forms (curls and waves). These secondary forms are made up of the individual strands of hair. Analyze hair form by going from general to specific.

On the head, the hair forms lie on the egg-shaped volume of the cranium. At the hair line, hair emerges from the scalp, and may proceed backward (keeping the hairline exposed) or forward (covering the hairline). Some hair forms may first pass backward from the hairline and then curve around forward to lie on the skin of the forehead or temple. A sharp line is found where these hair forms lie on the skin. Straight hair flows more gradually from one form into another than does wavy or curly hair. The hairline is usually located where the front plane of the forehead meets the top plane of the cranium.

The eyebrow is an arched row of densely packed hair which sits on the skin, fat, and muscle of the upper border of the bony orbit. Thicker medially, the eyebrow is generally, but not always, directed outward and upward, in contrast to the bone deep to it, which is directed outward and downward. The eyebrow functions as a highly movable area of high contrast which broadcasts facial expressions.

The facial hair consists of a mustache on each side of the upper lip and the beard. It too is composed of numerous forms, which are usu-

ally quite curly. The hair strands, and the forms they create, are directed inferiorly.

The pubic hair sits on the mound of the pubic fat pad, both of which cover and conceal the pubic symphysis.

Glands

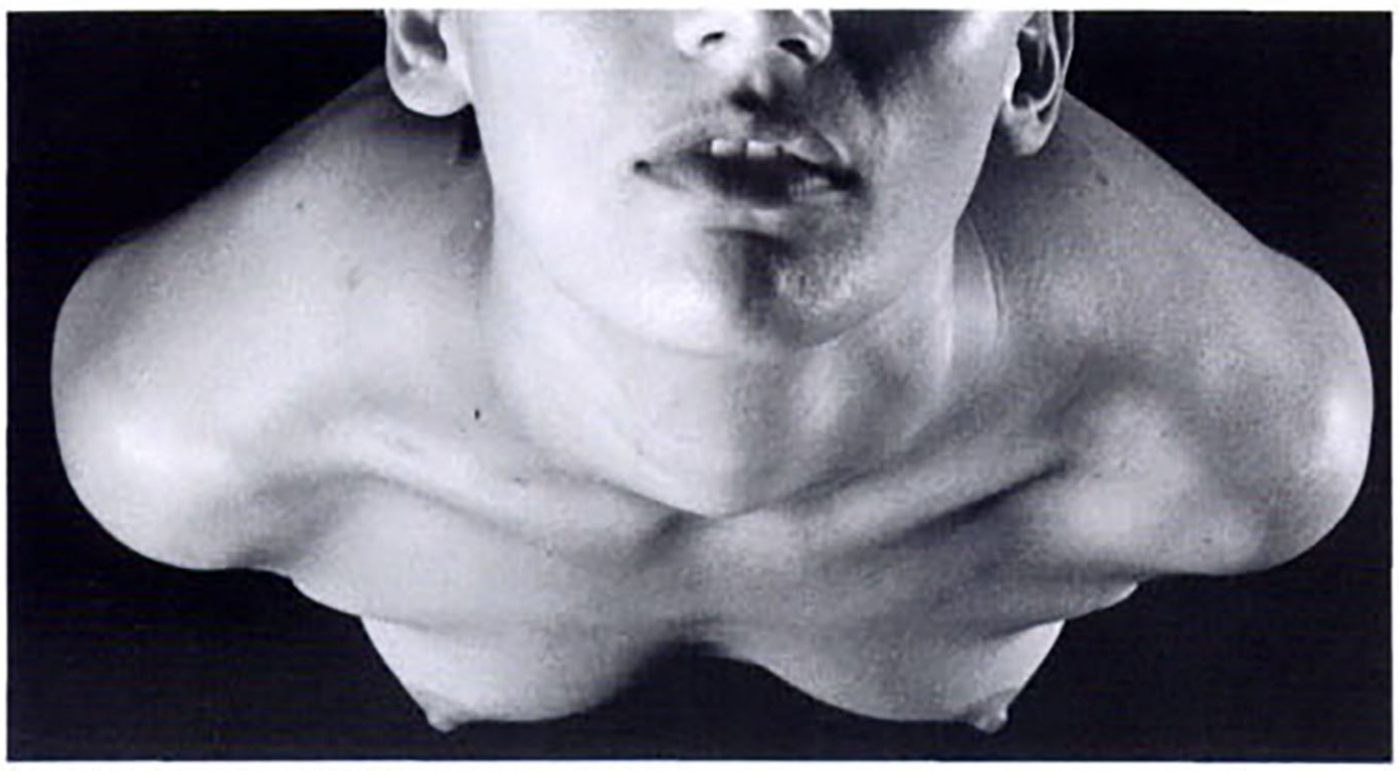
The **parotid gland** is located toward the back of the lower jaw. It overlies the posterior edge of the ramus of the mandible and the adjacent portion of the masseter. Approximately the size of the ear, it softens the back edge of the jaw.

The **submandibular gland** lies just inside the lower edge of the mandible, just anterior to the angle of the jaw. It sits in a recessed area of the bottom plane of the jaw and softens the form in this region.

The **thyroid gland** sits on the lower portion of the front of the neck, embracing the upper end of the trachea. It is larger in women, where it usually produces a soft swelling (see Throat).

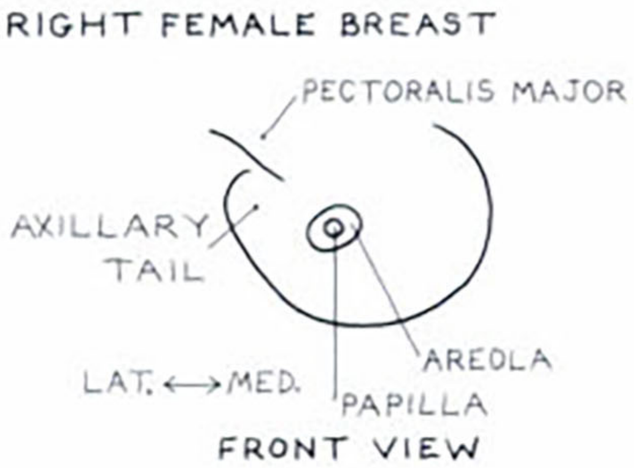
Female breasts

Female breasts



Female breasts—top view

Male nipple



The female *BREAST* is composed mostly of fat. The mammary glands are embedded within this fat, and are located toward the center of the breast. Breasts vary considerably in size and shape; classically they are seen as somewhat hemispherical forms. These forms have a lateral extension of variable size, the **axillary tail,** which extends slightly upward around the side of the chest toward the armpit. When the breast begins to sag, and if the axillary tail is developed, the form of the breast becomes horizontal—wider than it is high. Because of its weight, the breast hangs suspended by the skin of the chest above. This gives the upper portion of the breast a low convexity (down to the nipple) and the lower portion a round fullness of greater convexity (most noticeable in the side view profile).

Located between the third and sixth ribs, the breast lies on the lower part of the pectoralis major, covering its inferior and lateral borders, and on parts of the serratus anterior and external oblique. The breasts are separated from each other by a narrow interval at the sternum. Each breast points slightly to the side, not forward; the axes through the forms of the breasts are directed from the midline in the back of the body, where the two axes intersect, forward and outward through the nipples. The axes diverge anteriorly, most noticeable from the top view. Because of this divergence, when looking at the three-quarter view of the torso, the near breast is seen in its front view and the far one is seen in its profile.

The breasts first appear at puberty; with age they gradually flatten and develop a skin fold on their lower border as they hang over the surface of the rib cage. The soft form of the breast is quite movable on the rib cage; it changes position and shape as the figure changes pose—moving up when the arm is raised, flattening when lying on the back, becoming pendulous when leaning forward, etc. When the arm is raised, the breast becomes rounder and more hemispherical.

The short cylindrical or small hemispherical form of the **nipple** or **papilla** is usually located on the center of, or slightly above, the most projecting part of the breast. Its tip may be indented. The nipple lies on the round or elliptical **areola,** which has either a distinct, wide, raised conical form lying on the form of the breast or no form of its own at all, being distinguished from the breast by color alone.

The **male nipple** (papilla and areola) is located on the lateral side of the front of the chest, somewhere between the levels of the lower edge of the fourth rib and the upper edge of the sixth rib—just short of two head lengths down from the top of the head and usually just superior to the level of the infrasternal notch. It lies on the lower outer corner of the pectoralis major and on the thin, crescent-shaped pectoral fat pad when present. The nipples are commonly separated by just under a head length. (They are closer together than the anterior superior iliac spines of the pelvis.) In the front view, a line drawn from the acromion of the scapula to the navel passes through the nipple. The papilla is a small hemispherical form lying on a round or elliptical areola. When elliptical, it lies either horizontal or slightly oblique (inclined upward and inward). When the arms are raised, an elliptical areola becomes round, and a round areola becomes elliptical and vertical.

The *NAVEL,* or **umbilicus,** is the remaining scar of the attachment of the fetal umbilical cord. It is located on the linea alba on the midline of the abdomen, midway between the tip of the xiphoid process and the pubic symphysis, or slightly below. It lies near the levels of the highest part of the iliac crest of the pelvis and the middle of the flank portion of the external oblique (three head lengths down from the top of the head). The opening of the navel may be round or elliptical in a vertical or, more commonly, horizontal direction. An irregular fleshy swelling located within the depression of the navel may project past the opening, be flush with it, or be recessed, leaving a hole on the surface. Present usually at the upper edge of the hole, sometimes at its lower edge, and occasionally in both places, is a raised ridge. A slight depression is located external to the ridge—above and/or below the navel—depending on the location of the ridge. Fat accumulating around the navel, expecially below, obliterates the ridges and deepens the navel.

The female navel is typically surrounded by an accumulation of fat, especially inferiorly, and is therefore deeper, with its edges and ridges less defined.

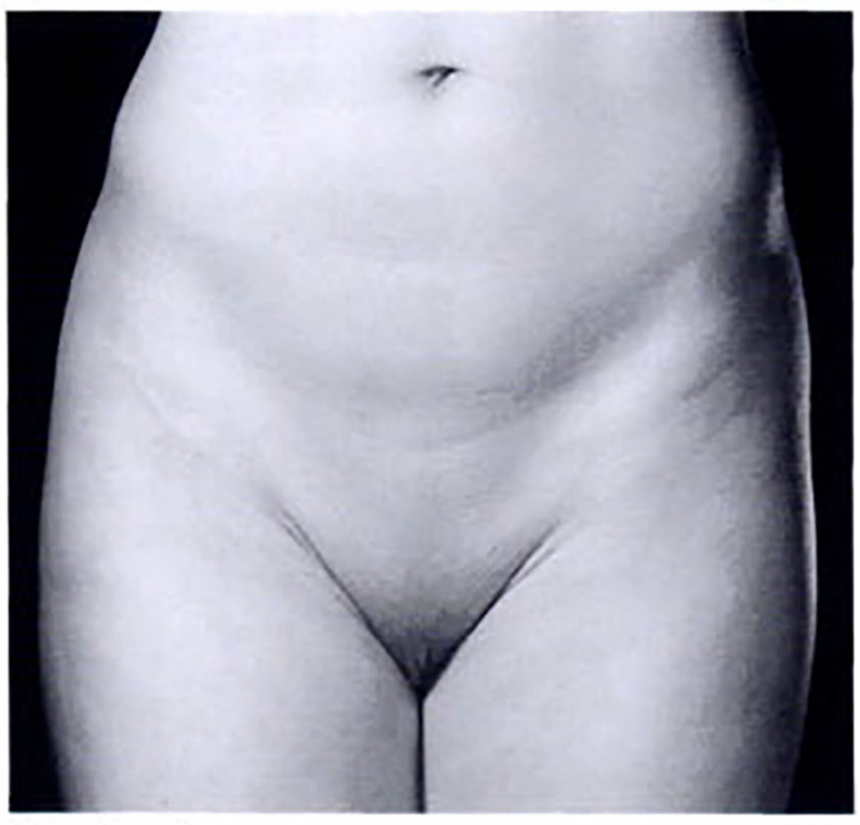
The *EXTERNAL GENITALIA* of the male consist of the penis and scrotum. The **penis** is a cylindrical form, consiting of a shaft, neck, glans penis, and, in the unncircumcised, a foreskin. The penis is connected at its base to the pubic arch of the pelvis, just below the pubic symphysis. The **shaft** projects slightly forward and then curves to hang downward. The distal portion of the shaft constricts slightly at the **neck** and then expands into the caplike **glans penis**—a cone whose rounded apex contains the slitlike urethral opening and whose base or edge, wider than the shaft, forms a ridge that progressively thickens anteriorly and dips into a V posteriorly. The surface of the glans is longer (higher) anteriorly than posteriorly, and a slight

Uncircumcised penis

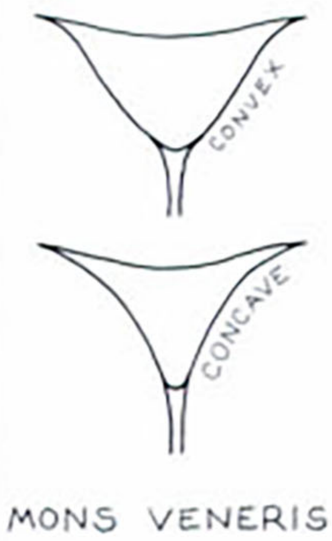
Uncircumcised penis

Circumcised penis

Circumcised penis



Female pubic region



Female pubic region

cleft on the posterior surface passes from the urethral opening upward to the posterior *V* notch of the ridge.

In the **uncircumcised penis,** the prolonged skin of the neck—the **foreskin** or **prepuce**—descends over the glans, forming a thin sleeve over it while still revealing its form underneath. The foreskin covers the glans to a varying degree; it may leave its tip partly exposed or may continue past it and constrict to form its own narrow, short skin tube. In the **circumcised penis,** the foreskin has been surgically cut off, and the glans is exposed. The tip of the penis may descend to a level at, above, or below the bottom of the scrotum.

The **scrotum** is a skin sack within which the two oval **testicles** lie obliquely, their long axes directed downward, backward, and slightly medially. The testicles may hang at the same or different levels, and one usually lies forward of the other. The weight of the testicles pulls the scrotum into two or three suspensory cutaneous cords on either side of the base of the penis. The scrotum rises when the body is cold and descends when it is warm, changing the ratio of the length of the scrotum to the penis.

The **external genitalia of the female** are usually concealed by the pubic hair. When the pubic hair is not present, as is typically depicted in art before the twentieth century, it is the soft, fatty, slightly convex, triangular mound—the **pubic fat pad,** or **mons Veneris**—that is seen. The upper edge of the pubic fat pad lies on the front of the pubic symphysis. The sides of the triangular mons, where they meet the legs, are either convex or concave, depending on whether the edge of the fat pad (convex) or the line of the thigh (concave) predominates. Its inferiorly pointed apex may show a vertical skin fold, which is the anterior portion of the cleft between the two **labia majora.** The flaplike **labia minora** may protrude downward from within this cleft.

Veins

The *SUPERFICIAL VEINS,* found in the superficial fascia just below the skin, transport the blood from the capillaries to the deeper veins, and then eventually to the heart. They are usually studied by tracing their pathways from the smaller capillaries toward the heart, which is the direction of the blood flow. The venous vessels form a branching bush, but unlike the arteries, which begin at the large arterial trunks and progressively split into smaller branches, the veins begin at the smallest branches, which unite to form progressively larger and wider vessels, until finally reaching the heart (based on the direction of blood flow). The surface pattern of the venous system is more variable at the smaller, branched capillary ends and more constant as they unify and enlarge in their approach to the heart. For this reason, it is easier to trace the patterns of the veins on the surface by first locating them where they are largest and enter the body and then backtracking to follow them as they branch into smaller and narrower vessels—opposite the direction of blood flow. This is how they will be presented in this section.

The veins appear bluish under the skin; they become full and bulging during and after muscular exertion, or engorge because of the influence of gravity on the blood. The blood drains from the limbs when they are raised upward, and as the blood drains from a vein, the vein may appear as a shallow furrow. The veins are more readily seen in persons with little body fat. **Valves,** located in the veins to prevent backflow of the blood, appear as knotty bulges in the veins. The complex network of the small veins can easily confuse surface form, and in recreating them in artwork, care must be taken to balance the prominence of veins in relation to the important structural forms of the bones, muscles, and tendons beneath them.

The pattern of the veins varies greatly from individual to individual, as well as from the left side of the body to the right side, even in the same individual. A vein on one side of the body may be larger than its counterpart on the other side.

The **major points of entry** of the superficial veins are as follows: *above the clavicle* (draining the head and neck), *below the clavicle* (draining the outside of the upper limb), *inside the upper arm* (draining the inside of the upper limb), *below the inguinal ligament* (draining the lower limb and lower trunk), and *the back of the knee* (draining the back of the lower leg).

The larger, more prominent veins are followed by a double asterisk (**), and those less prominent by a single asterisk (*); noticeable branches have no asterisk.

HEAD The **supratrochlear (frontal) vein** * is located near the midline on the front of the forehead. It passes from the top of the forehead to the side of the root of the nose (medial to the inner end of the eyebrow) and heads to the upper inner corner of the bony orbit. The veins of both sides may join on the upper forehead to form a single, more pronounced vein, located on or to one side of the midline of the forehead. Inferiorly, it splits at the root of the nose.

The **superficial temporal vein** is located on the side of the head on the temple. Inferiorly, it passes downward over the posterior end of the zygomatic arch (just in front of the ear) and then passes deeply behind the condyle of the mandible. Superiorly, this vein splits into anterior and posterior branches. It is straighter, thicker, and usually more vertical than the superficial temporal artery.

The **superficial temporal *artery*** passes upward over the posterior end of the zygomatic arch (just in front of the ear) and then soon branches. The oblique anterior branch, or **frontal branch,** located on the temple, passes forward and upward toward the forehead. It is often quite conspicuous and tortuous in its course, and a pulse can be felt when pressing it. It becomes more prominent in the elderly.

NECK The **external jugular vein** ** sits vertically on the side of the neck and is directed from the fossa above the clavicle (immediately lateral to the clavicular head of the sternomastoid) upward toward the angle of the jaw. It crosses over the oblique sternomastoid and lies under the platysma.

The vertical **anterior jugular vein** * is located variably between the midline of the neck and the front edge of the sternomastoid. It usually descends on the surface of the sternohyoid. Superiorly, it sits on the side of the hyoid bone, and inferiorly it disappears under the sternomastoid at the base of the neck near the pit of the neck. There may be an anterior jugular vein on each side of the neck (one for each side of the body) or only a single vein for the entire neck, on the midline, which may become quite large.

A **branch to the external jugular vein** * passes downward, outward, and backward across the surface of the sternomastoid to reach the middle or lower portion of the external jugular vein. It is present quite regularly and is seen along with the external jugular vein during exertion.

ARM The **cephalic vein** ** begins just under the clavicle (in the infraclavicular fossa) and first descends between the pectoralis major and deltoid (defining the separation between these two muscles). It then passes downward on the biceps, along the lateral side of the surface of the

belly (no longer between the two muscles). Before reaching the elbow, it becomes lodged between the biceps and brachioradialis. It then curves over to the front of the elbow region and descends halfway down on the front of the forearm (on the brachioradialis). Next it curves laterally and descends on the outer (radial) side of the forearm, passing down the center of the "anatomical snuffbox." The cephalic vein technically ends where it joins the dorsal venous network on the radial (thumb) side of the back of the hand.

Just before the cephalic vein curves around toward the front of the elbow, the **accessory cephalic vein** * branches off. This vein descends on the outer front corner (radial side) of the forearm and then branches into smaller veins on the back of the forearm or hand.

The **basilic vein** * first appears halfway down the inside of the upper arm, between the biceps and triceps. It then descends on the medial surface of the biceps and continues down the flexor muscle mass of the forearm (passing in front of the medial epicondyle of the humerus). It soon curves around to the ulnar (inner) side of the forearm and descends on the back of the forearm, along its ulnar side. It eventually reaches the dorsal venous network on the ulnar side of the back of the hand.

On the inside of the front of the elbow, the basilic vein sends off the short but very prominent **median cubital vein** **. This vein passes downward and medially on the front of the elbow, on top of the bicipital aponeurosis. It soon joins the cephalic vein. The veins on the front of the elbow together form an M-shaped pattern, made up of (from lateral to medial) the accessory cephalic, cephalic, median cubital, and basilic veins.

The **median antebrachial vein** * passes down the middle of the front of the forearm. Inferiorly, it branches into smaller veins as it approaches the palmar side of the wrist. Superiorly, it originates from either the basilic or median cubital veins. It may fork superiorly, originating from both. There is much venous variation on the front of the forearm.

The **dorsal venous network** * on the back of the hand can be visualized as a zigzagged, downwardly curved connecting loop between the cephalic vein on the radial side of the back of the hand and the basilic vein on the ulnar side. It sends off three veins to fingers two through five, the **dorsal metacarpal veins,** which descend between the knuckles and then pass down either side of the fingers as the **dorsal digital veins.** The dorsal digital vein of the thumb comes directly off the inferior end of the cephalic vein on the back of the first metacarpal. The veins on the back of the hand are numerous, prominent, and complicated, especially when engorged. They remain prominent down through the dorsal surfaces of the proximal phalanges. Veins do not appear on the palmar side of the hand or the fingers, except on the base of the hand near the wrist.

LEG The **great saphenous vein** ** is the longest vein in the body, extending from the groin to the foot. It is thickest where it enters the body just below the inguinal ligament, at the superior end of the front of the thigh near the groin. From here it descends slightly medially and posteriorly on the adductor muscles (adductor longus) and then on the sartorius. It courses downward over the inner back corner of the knee, still on the sartorius. Moving anteriorly again, it passes downward on the front surfaces of the gastrocnemius and soleus (near to, but not touching, the shaft of the tibia), passes obliquely downward and forward across the lower third of the medial surface of the shaft of the tibia, continues down the *front* of the medial malleolus, passes down the top or side of the big toe's metatarsal, and finally ends where it joins the dorsal venous arch of the foot on its medial side.

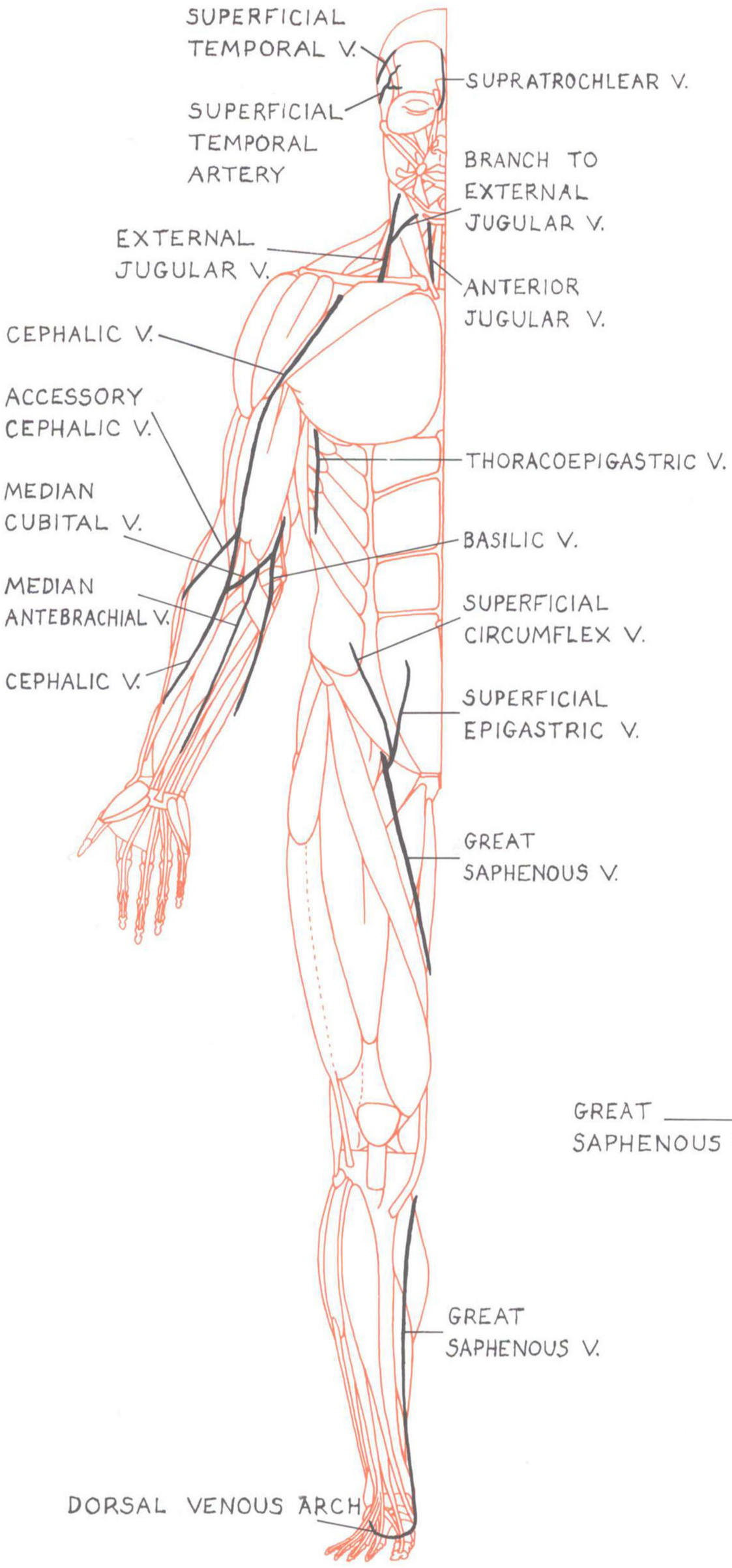
The **small saphenous vein** * emerges from the popliteal fossa at the back of the knee, passes down the back of the calf between the heads of the gastrocnemius, gently veers laterally to pass down the lateral edge of the Achilles tendon, hooks *behind* the lateral malleolus of the fibula, and finally curves anteriorly and passes along the outer side of the foot to join the dorsal venous arch of the foot. Just above the ankle, this vein may send branches downward and forward, which pass over the outer surface of the lateral malleolus.

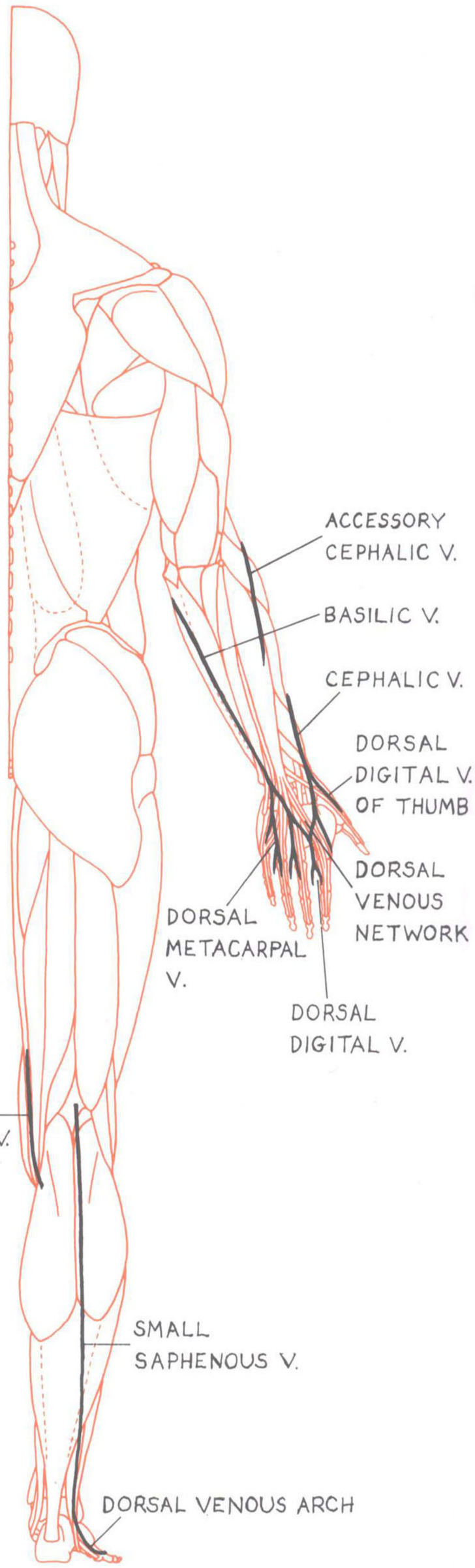
The **dorsal venous arch,** lying on top of the distal ends of the shafts of the metatarsals of the foot, forms a loop connecting the great saphenous vein on the medial side of the foot with the small saphenous vein on its lateral side. The numerous remaining veins on the foot show a highly irregular pattern.

TRUNK The **thoracoepigastric vein** begins in the armpit and passes vertically downward over the digitations of the serratus anterior.

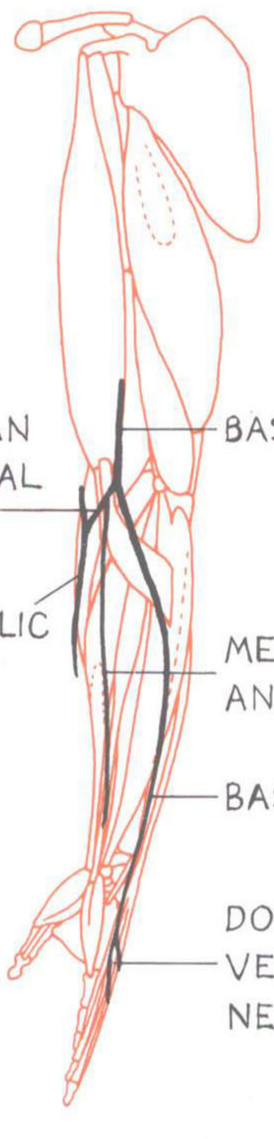
The oblique **superficial epigastric vein** * is located on the front of the lower abdomen, below the navel and above the inguinal ligament. It passes upward and slightly medially from the femoral triangle of the thigh, crosses over the inguinal ligament, and ascends on the surface of the rectus abdominis (it begins at the upper end of the great saphenous vein on the thigh). Near the inguinal ligament, this vein forks and sends a lateral branch, the **superficial iliac circumflex vein,** upward over the triangular tendinous expansion of the external oblique.

Veins

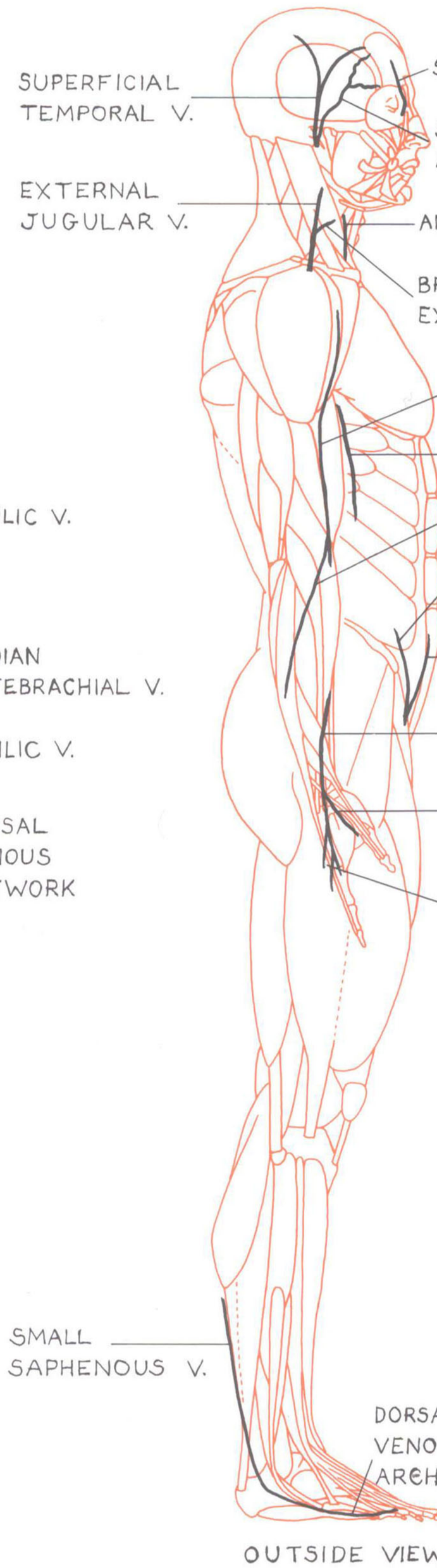

SUPERFICIAL TEMPORAL V.
SUPERFICIAL TEMPORAL ARTERY
EXTERNAL JUGULAR V.
CEPHALIC V.
ACCESSORY CEPHALIC V.
MEDIAN CUBITAL V.
MEDIAN ANTEBRACHIAL V.
CEPHALIC V.
SUPRATROCHLEAR V.
BRANCH TO EXTERNAL JUGULAR V.
ANTERIOR JUGULAR V.
THORACOEPIGASTRIC V.
BASILIC V.
SUPERFICIAL CIRCUMFLEX V.
SUPERFICIAL EPIGASTRIC V.
GREAT SAPHENOUS V.
GREAT SAPHENOUS V.
DORSAL VENOUS ARCH
FRONT VIEW


ACCESSORY CEPHALIC V.
BASILIC V.
CEPHALIC V.
DORSAL DIGITAL V. OF THUMB
DORSAL VENOUS NETWORK
DORSAL METACARPAL V.
DORSAL DIGITAL V.
GREAT SAPHENOUS V.
SMALL SAPHENOUS V.
DORSAL VENOUS ARCH
BACK VIEW

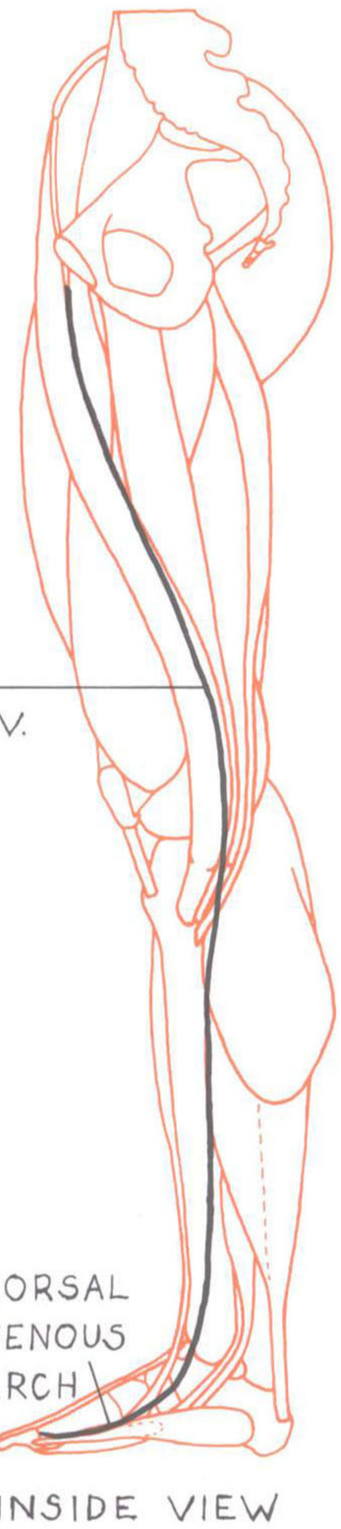
Veins



INSIDE VIEW

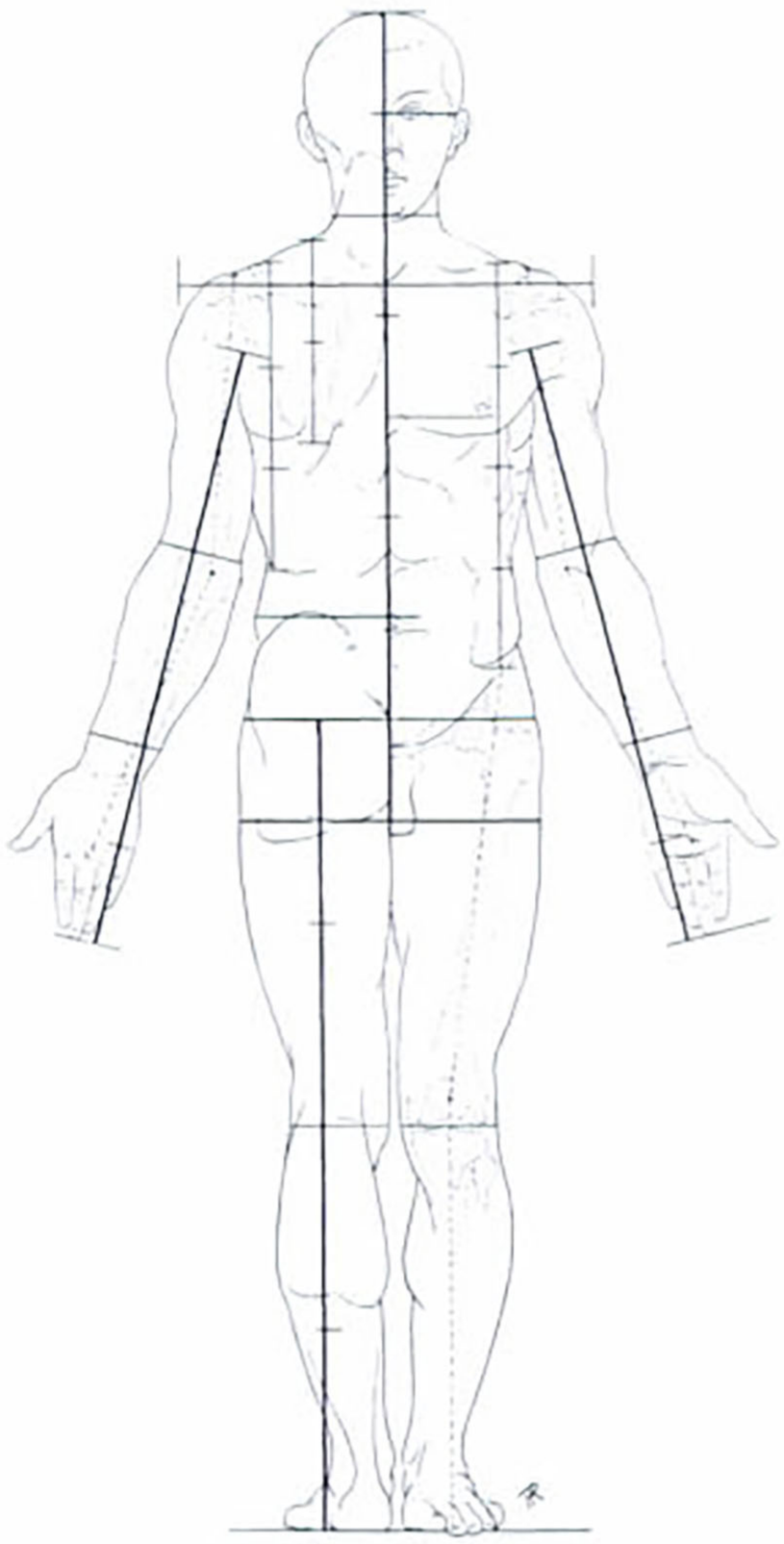


OUTSIDE VIEW

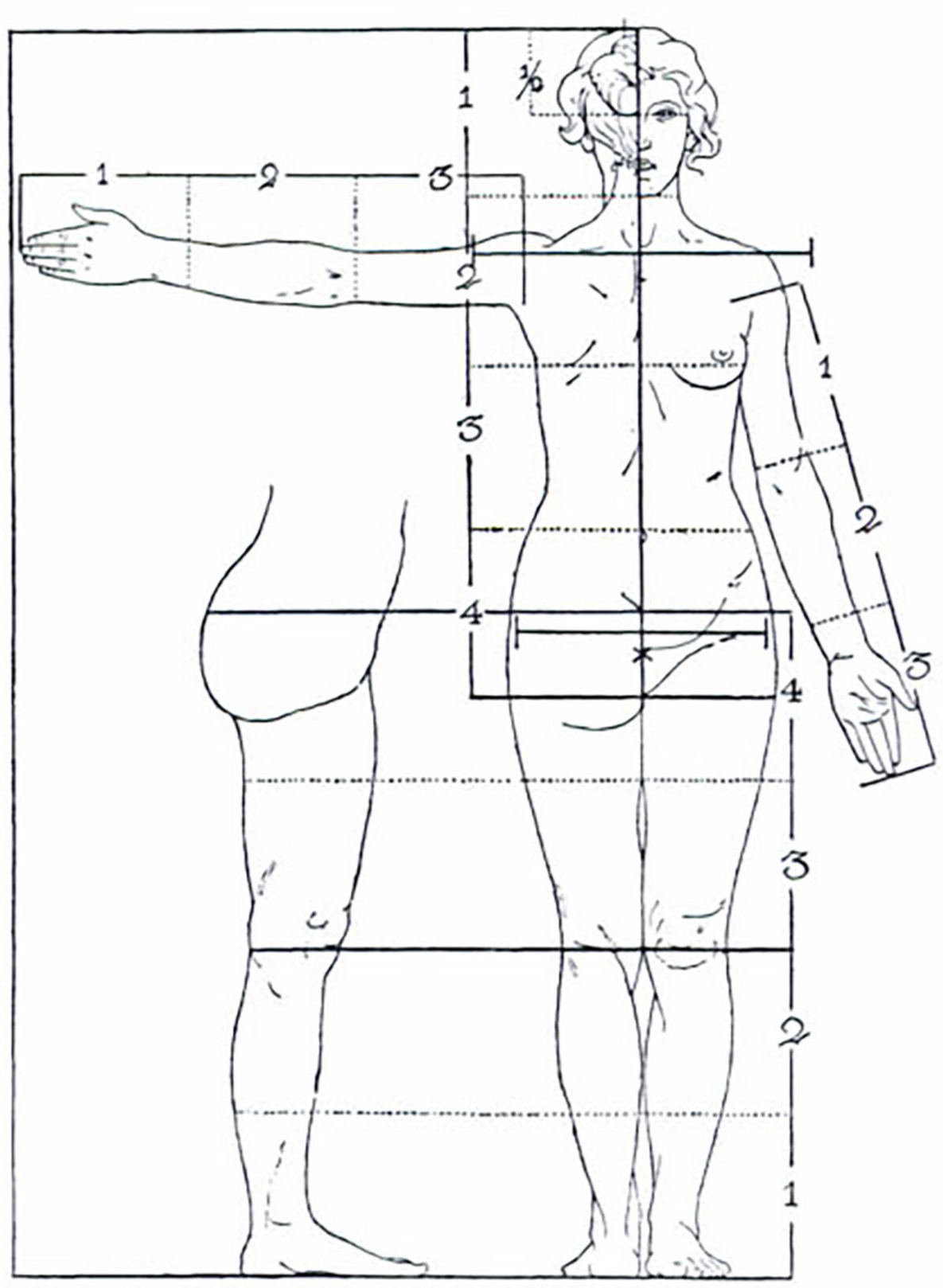


INSIDE VIEW

Proportion



Paul Richer—1890



Paul Richer—1920

Proportion

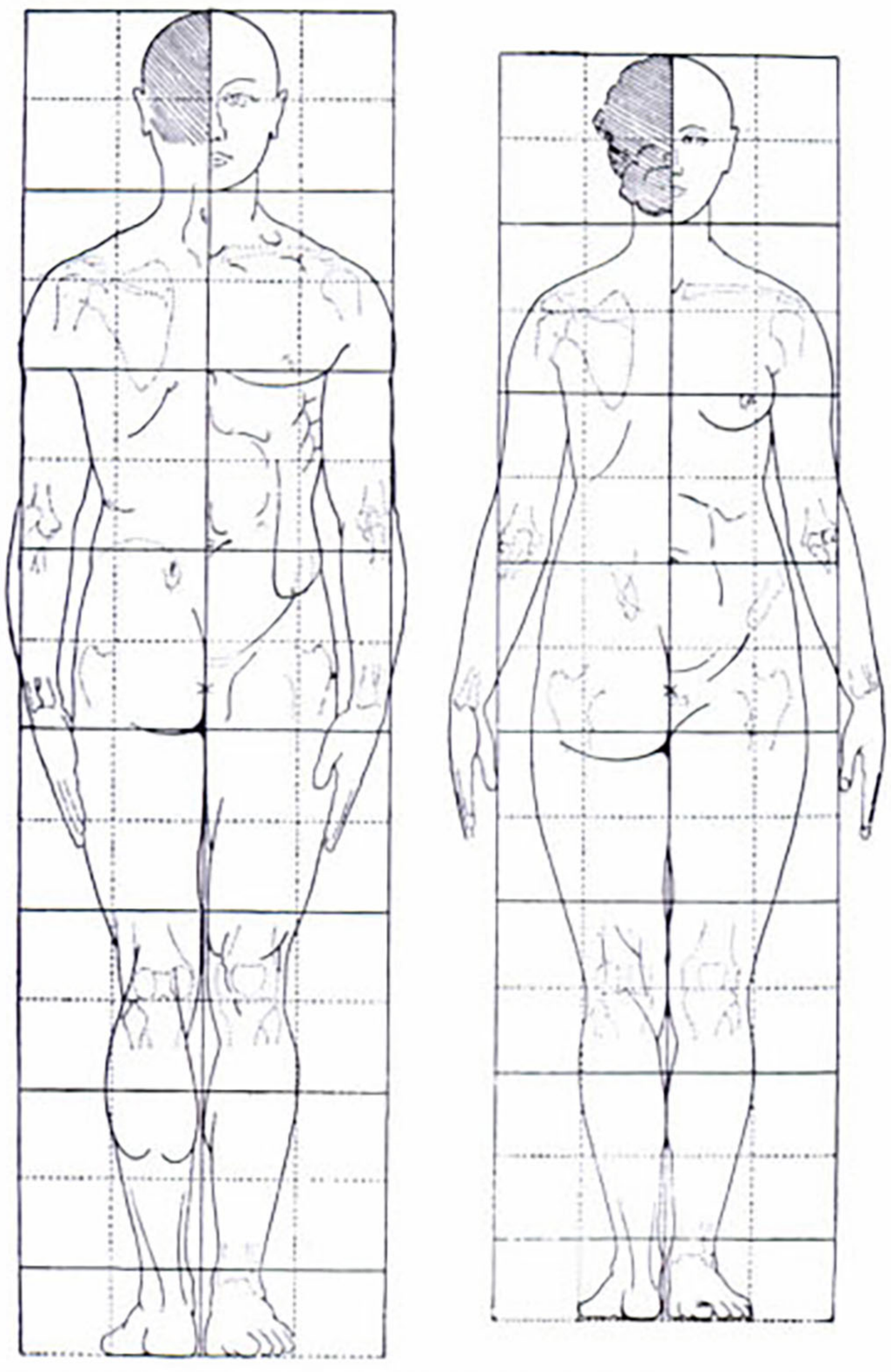
PROPORTION is the most subjective aspect of the study of human structure. Our understanding of proportion is based on a combination of several factors: historical conceptions of the figure throughout art history (it also varied in different geographical regions during the same time period, e.g., German and Italian Renaissance), society's present standard of beauty, our own particular sensibilities as an artist, and, when working from the live model, the particular set of proportions of that individual.

Proportion deals with *comparisons*—a height to another height, a height to a width, a height to a depth, a width to a depth, etc. Useful lengths are those that are equal to another length or are multiples of that length (twice as long, three and a half times as long, etc.). The figure, or its components, can also be divided into equal units, such as halves, thirds, fourths, etc. A common unit of measurement for the body is a head length (head height), which can, for example, be divided into the figure six, seven, seven and one-half, eight, or even more times, each having very different results.

The body can be measured from its bony landmarks (top and bottom of the sternum, medial epicondyle of the humerus, front point of the pelvis, patella, etc.) and from its fleshy landmarks (nipple, navel, horizontal gluteal fold, etc.). Fleshy landmarks are more variable among individuals, and tend to shift when the figure changes pose.

Finally, and obviously, proportions vary according to age, sex, and race.

The following illustrations present some traditional systems of proportion developed by well-known artist/anatomists.



PROPORTIONS OF MALE AND FEMALE FIGURES IN HEADS AND HALF-HEADS

Arthur Thomson—1896

FIG. 129.—GENERAL COMPARATIVE PROPORTIONS.

1. From Plinth to top of Patella.
2. From centre of Patella to Iliac process.
3. From Pubic line to top of Sternum.

These three proportions are generally equal.

THE ARM.

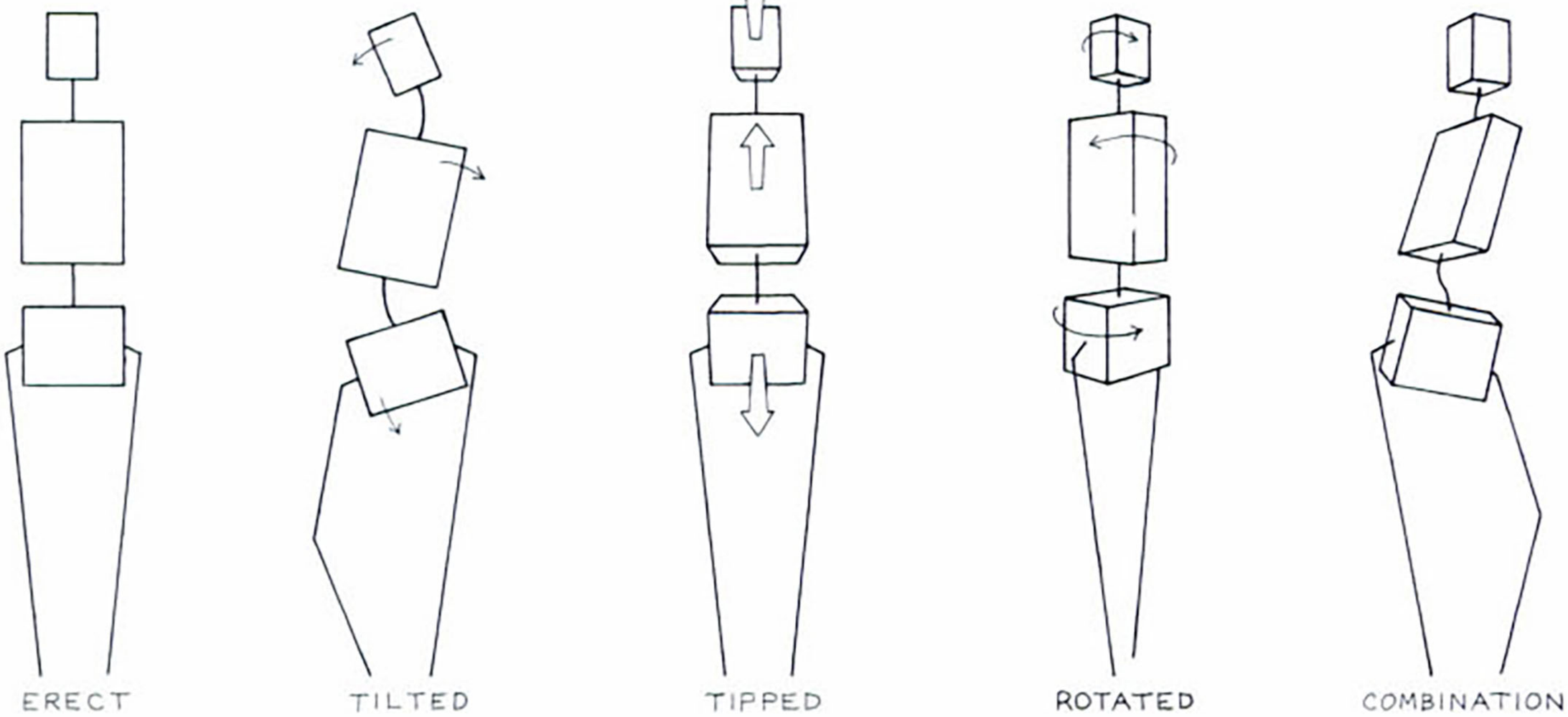
4. Three heads in length from Acromion to first articulation of index finger.
5. From Acromion to head of Ulna one head and a half.
6. From head of Ulna to first articulation of finger one head and a half.

From Plinth to top of Patella two heads.
From centre of Patella to Iliac process two heads.

Edouard Lanteri—1922

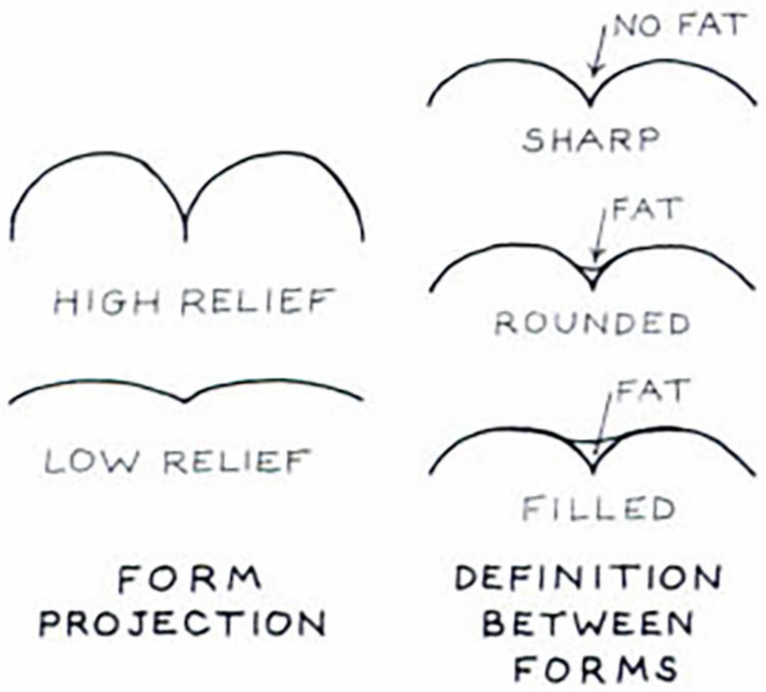
Mass Conceptions of the Figure

VOLUME RELATIONSHIPS

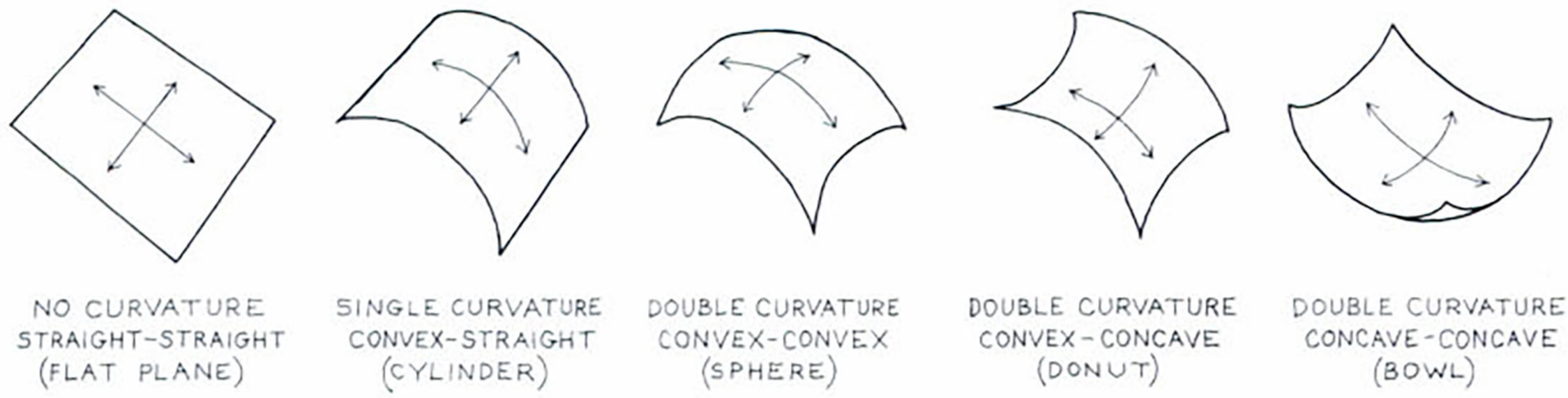


EDGES

FORM DEFINITION



SURFACES



Mass Conceptions of the Figure

A *MASS CONCEPTION* is a three-dimensional "idea" of a complex shape in nature, reducing many interrelated forms of varying sizes into a simple, easily remembered, geometric volume. Much the same way as the planet Earth can be diagrammatically represented as a two-dimensional circle or a three-dimensional sphere, the human body, albeit much more complicated, can be reduced to certain basic geometric volumes. These volumes can begin as the most basic cubes and spheres and then be modified into more complex forms, such as rectangular prisms, cylinders, and cones. Further development produces ovoid forms with double-curved convex surfaces and then forms having combined shapes (oval and cube together) with multiple planes. This progression leads to more complex organic masses, and ultimately evolves into realistic human form. The function of developing a mass conception is to create an understanding of the basic essence of each region of the body, its axis (position in space), as well as the orientation of its planes, before considering its details (anatomy). It is a process of working from *large* to *small,* from *simple* to *complex,* or from the *whole* to the *part.*

The head, thorax, and pelvic region are the three main body masses. These regions are not based on the skeleton alone, but on the muscles, cartilage, and fat as well. They are connected to each other by the vertebral column, and can independently be tilted, tipped, and rotated in relation to each other. The limb segments (upper arm, forearm, foot, etc.) are elongated masses. The overall mass of the hand or foot can be subdivided into smaller, elongated masses for the individual fingers and toes and then into separate masses for the phalanges. Abrupt change of direction in space between adjacent body masses produces a dynamic figure; conversely, less angulation between masses produces a more harmonious, flowing figure.

For the figure to maintain its equilibrium, the body masses, and therefore the overall center of gravity (or center of mass) of the entire figure, must be balanced over a base of support, usually the feet. When the center of gravity does not lie above the base of support, the figure becomes unstable and will fall. During motion, the center of gravity repeatedly moves in and out of the base of support.

Formulating mass conceptions is a traditional method that artists have used to understand and then re-create complex form in nature. Albrecht Dürer (1471–1528), Luca Cambiaso (1527–1585), and George Bridgman (1864–1943) developed fine, esthetic mass conceptions of the figure. Presented below are suggestions for various mass conceptions. Artists must invent their own personal conception of the figure—one that constantly changes as their relationship with the figure develops. The figure, *when rendered in clearly conceived masses,* regardless of the amount of detail presented, produces a powerful artistic statement.

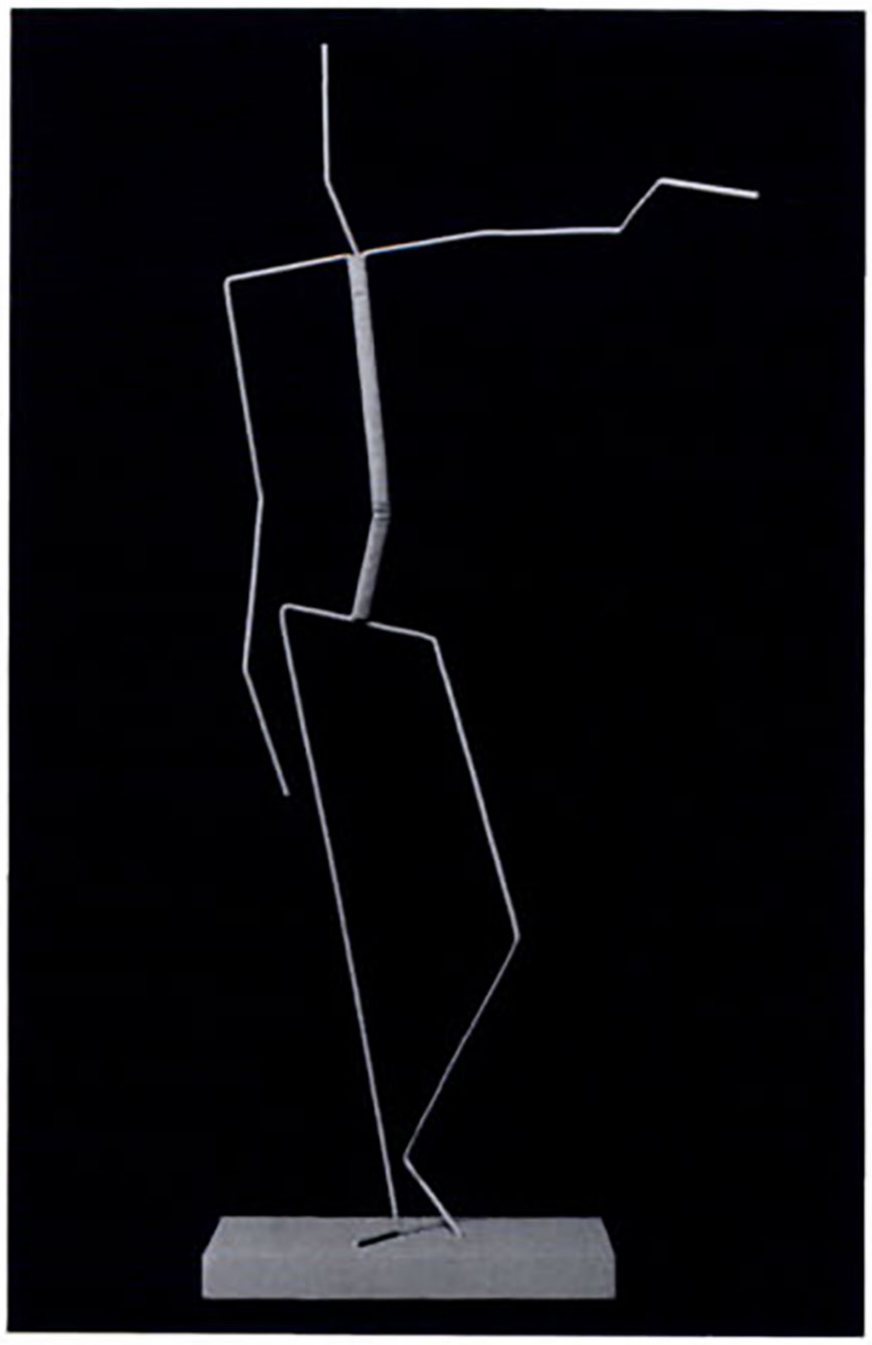
Surfaces

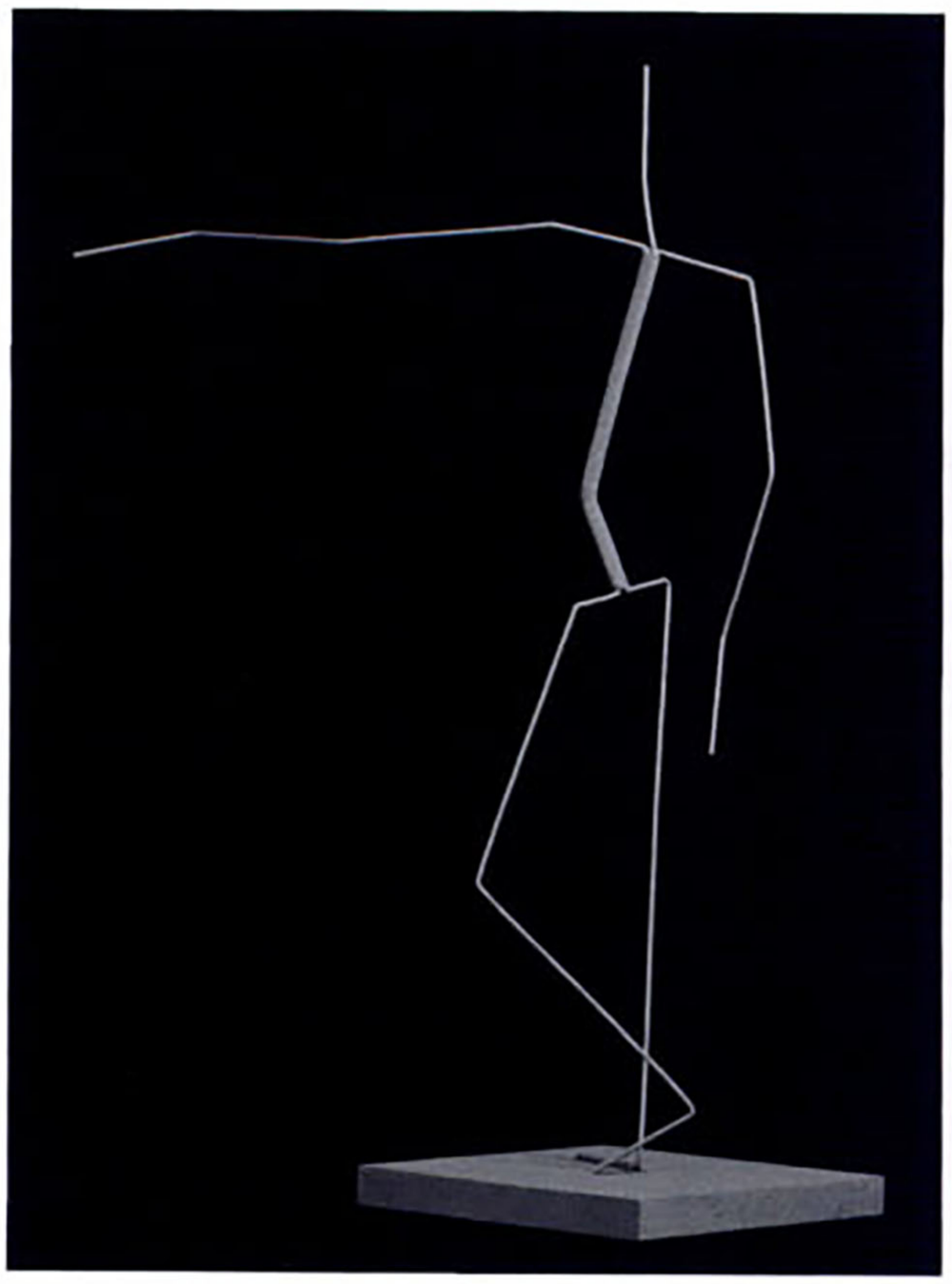
A **plane** represents the flattened or curved *sum total* of a complex area containing many forms, or the actual surface of a single form. It has **orientation,** which is the direction that particular surface is facing, such as upward, downward, outward, inward, forward, or backward, or a combination of up to three of these directions. Visualizing a complex area of the figure in terms of a simple plane consolidates it so that can be better understood and then re-created in art, the same way a line simplifies numerous consecutive points into a single curved or straight line. Adjacent planes meet at **edges,** which are oftentimes specific anatomical structures. The more acute the angle of the meeting of the planes, the more prominent the edge. The live model can be lit to define those structural planes that normally occur in life.

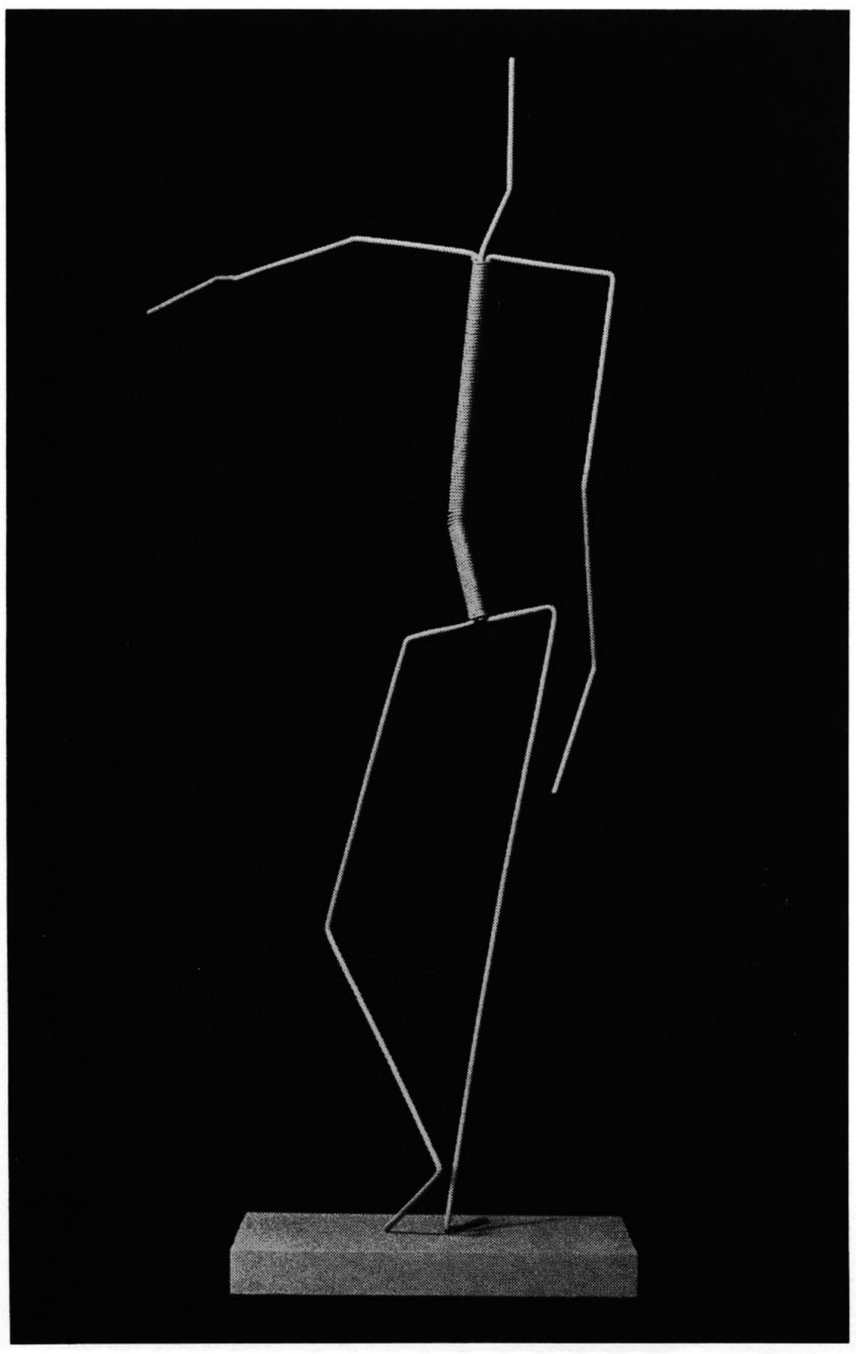
TYPES OF PLANES Planes are categorized by their surface curvature or flatness into the following: **flat** (both directions straight), **convex/straight** (as in the surface of a cylinder or cone—one direction rounded, the other straight), **convex/convex** (as in the surface of a sphere—both directions rounded), **convex/concave** (as in the surface area of a doughnut surrounding the hole—one direction bulging, the other hollowed), and **concave/concave** (as in the inside surface of a bowl—both directions hollowed). The flat plane is rare in the figure and is used more conceptually. The concave/concave plane is also rare (philtrum under the nose, pit of the neck, palm), but is quite common on the skeleton (the full volumes of the muscles sit in the hollows of the skeleton). The convex/concave plane is uncommon (Achilles tendon, columns created by the trapezius on the back of neck, tendon of tibialis anterior on the front of the ankle). The convex/flat plane is also uncommon—the straight direction usually turns out to be slightly convex. The convex/convex plane is the most common, because the entire surface of the figure is created by the assemblage of numerous volumetric bulging forms (the anatomical components), placed side by side or one on top of the other (usually small forms on top of large forms).

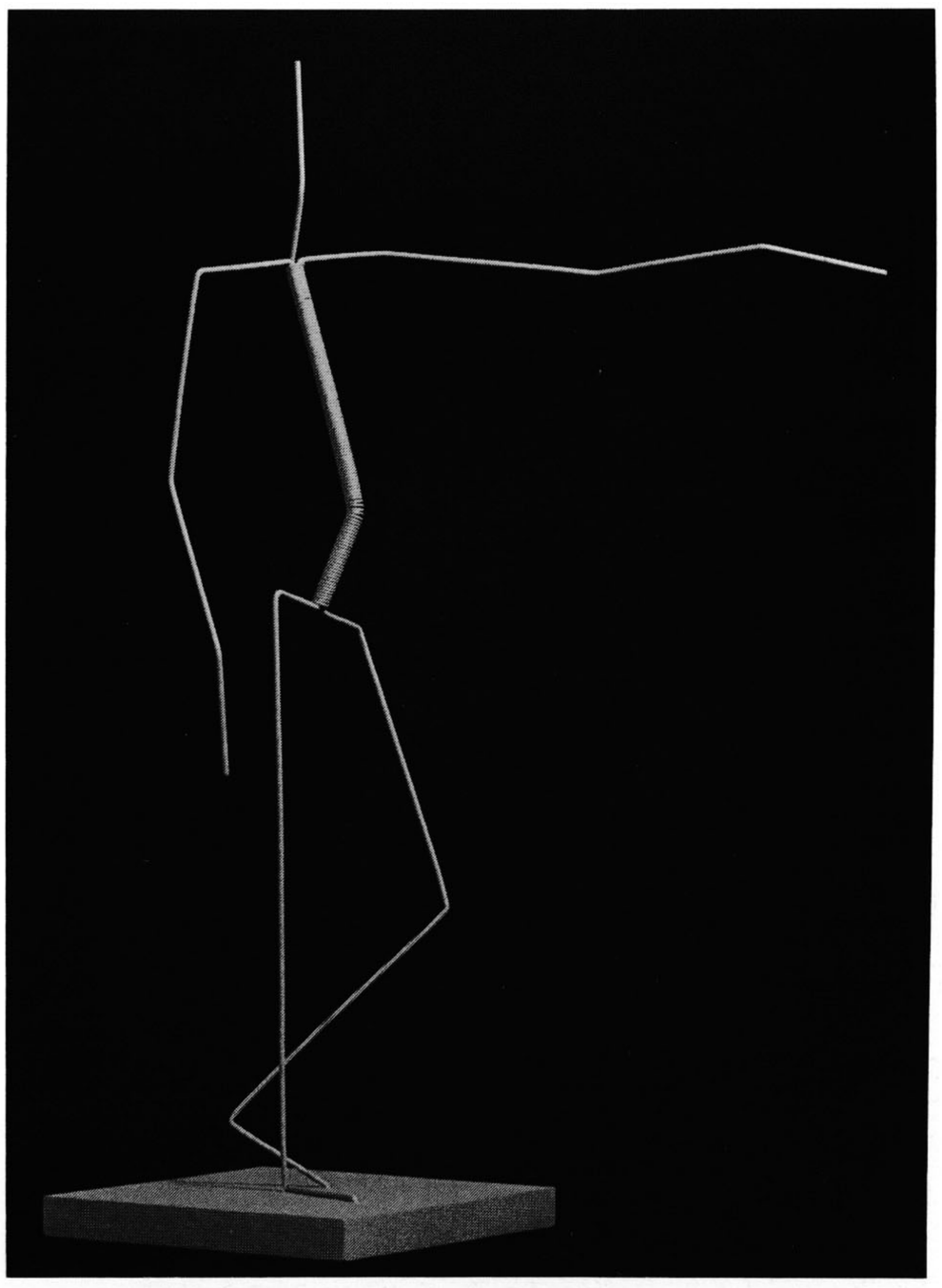
RELATIONSHIP BETWEEN FORMS *All form in the figure is produced by anatomy*—bone, cartilage, muscle, tendon, fat, skin, veins, etc. Besides the usual geometric shapes, forms in the figure are often **teardrop** or **fusiform** (tapering toward each end). Forms can be considered in **high** or **low relief** depending on their projection from the surrounding surface, independent of the definition between them. **Definition** between forms varies, depending on the degree of subcutaneous fat and the amount of contraction of the muscles. The contact between forms can be *sharp* (cleft, cleavage), *rounded* (furrow, groove), or *obscured* (filled—continuous surface between forms). On close examinatioin of the figure, its individual forms can be isolated and their borders defined. Capturing this extensive network of interrelated surface forms, or **surface modeling,** in an accurate way gives artwork great fidelity to nature, vitality, and realism.

Axes

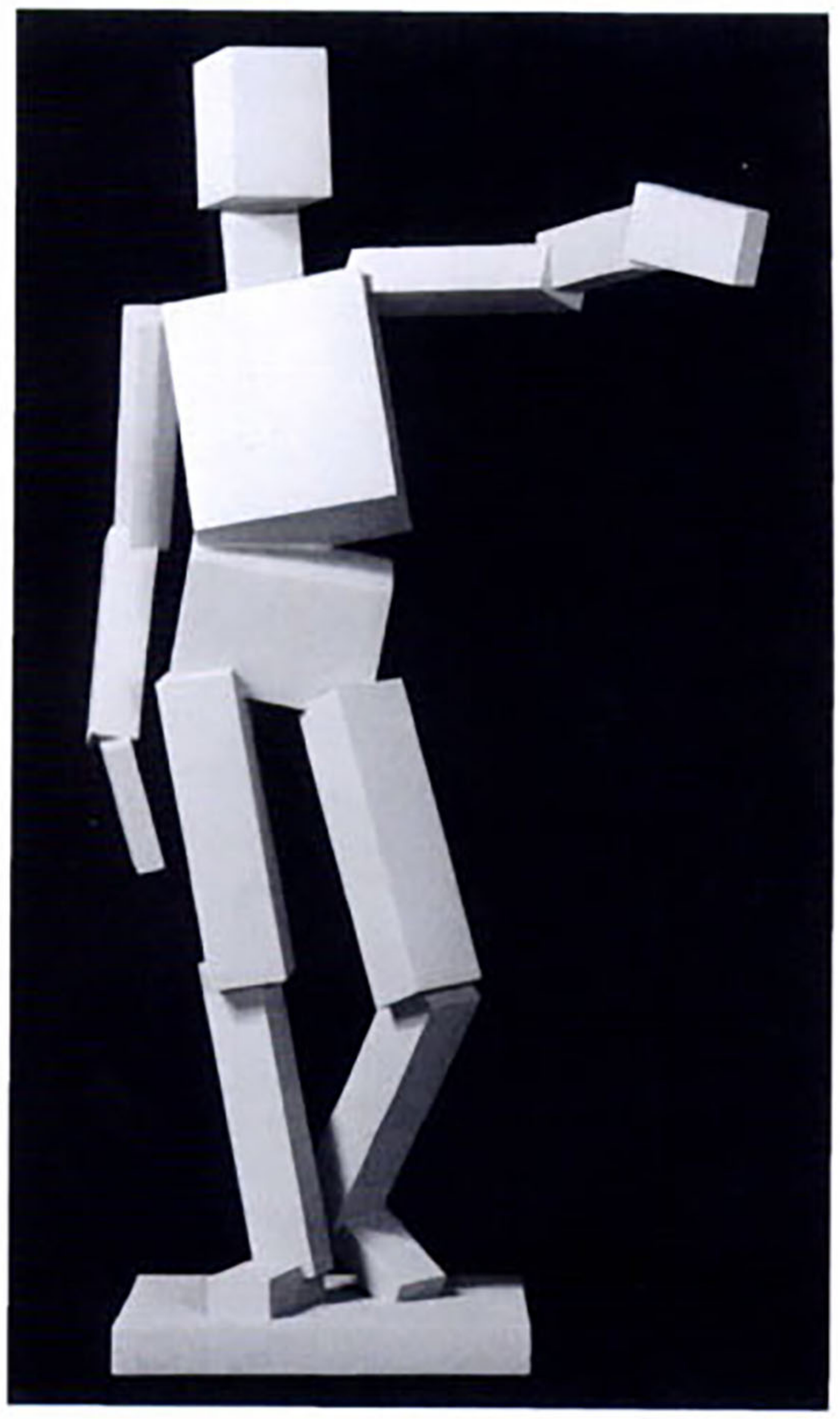


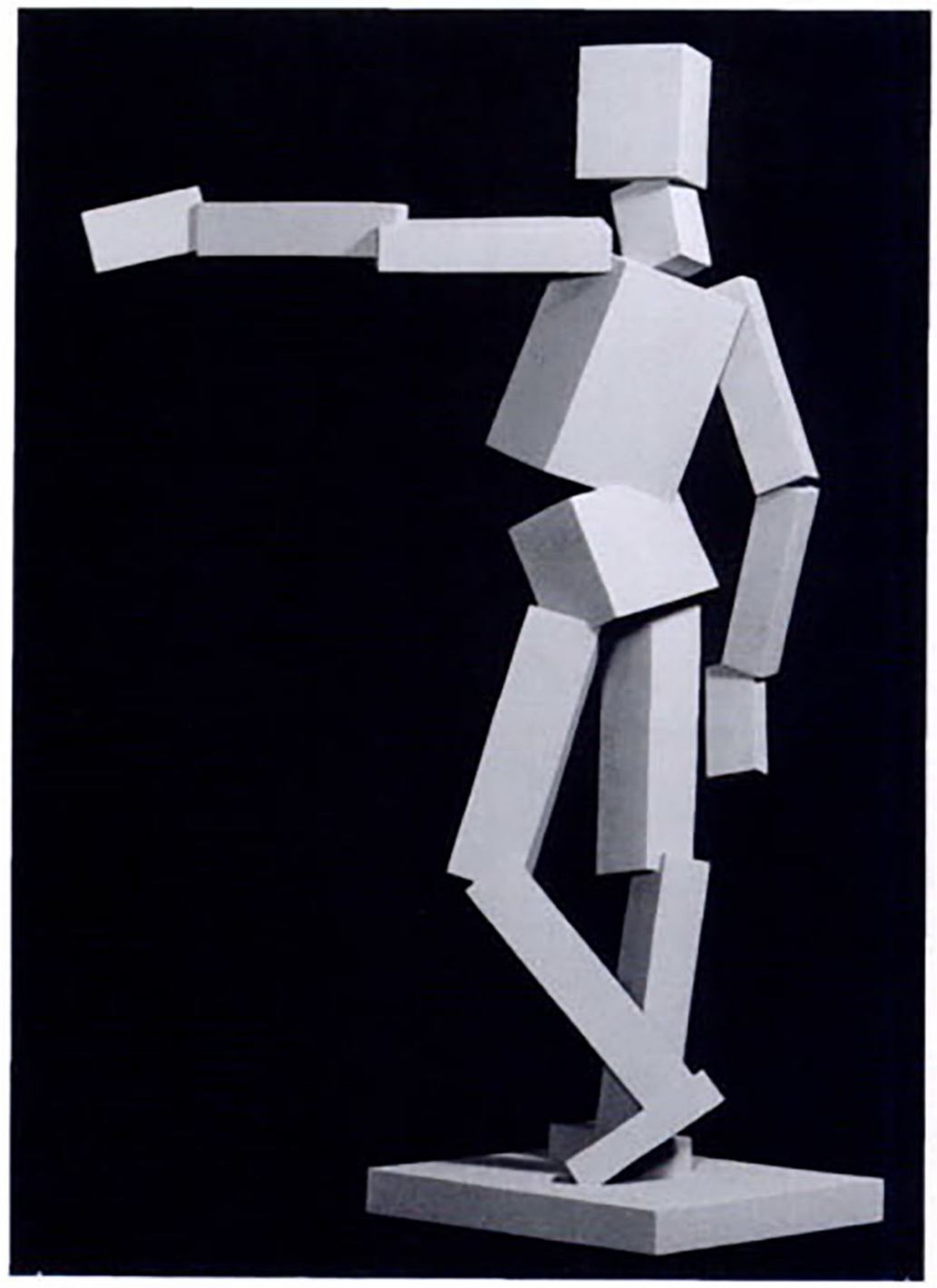




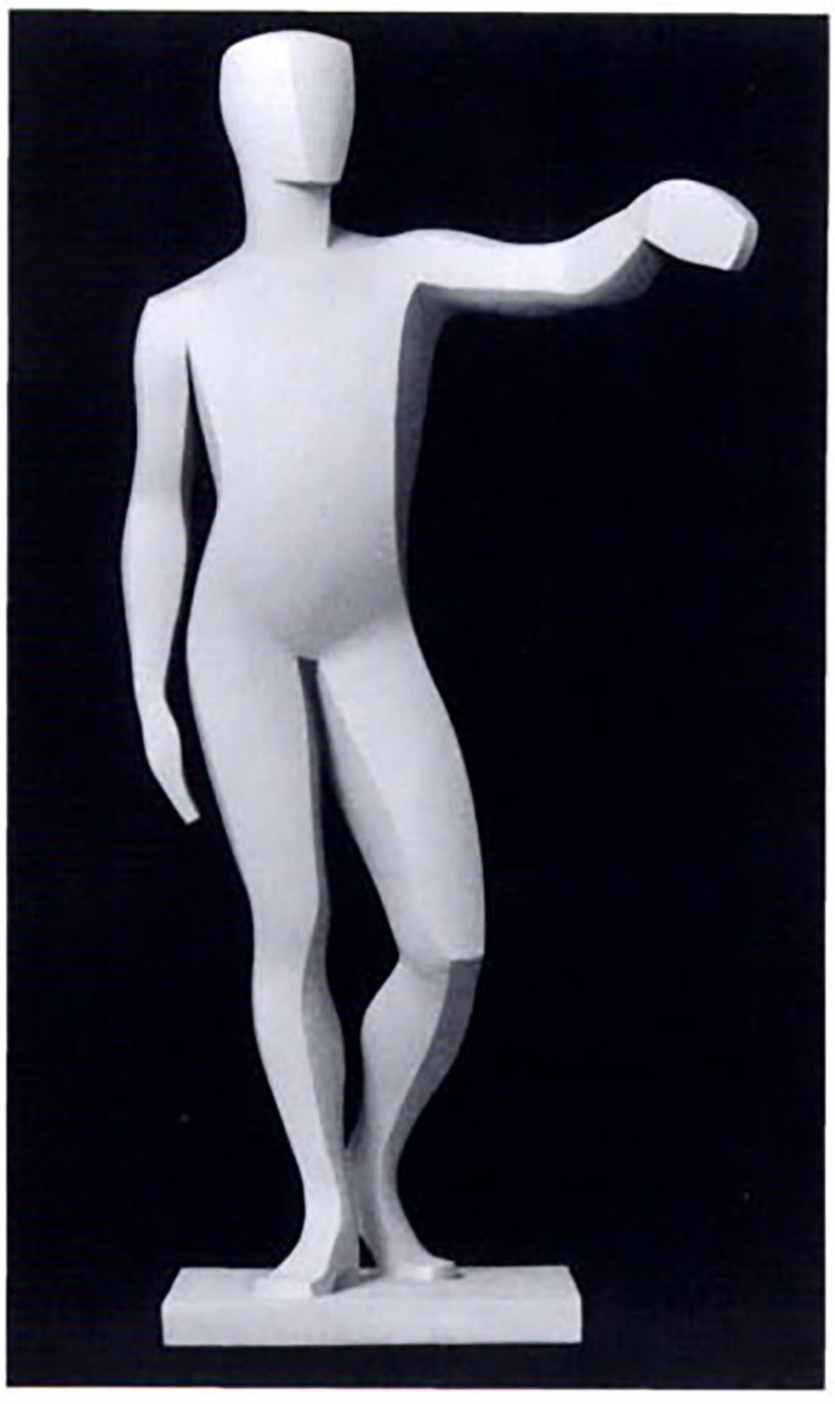


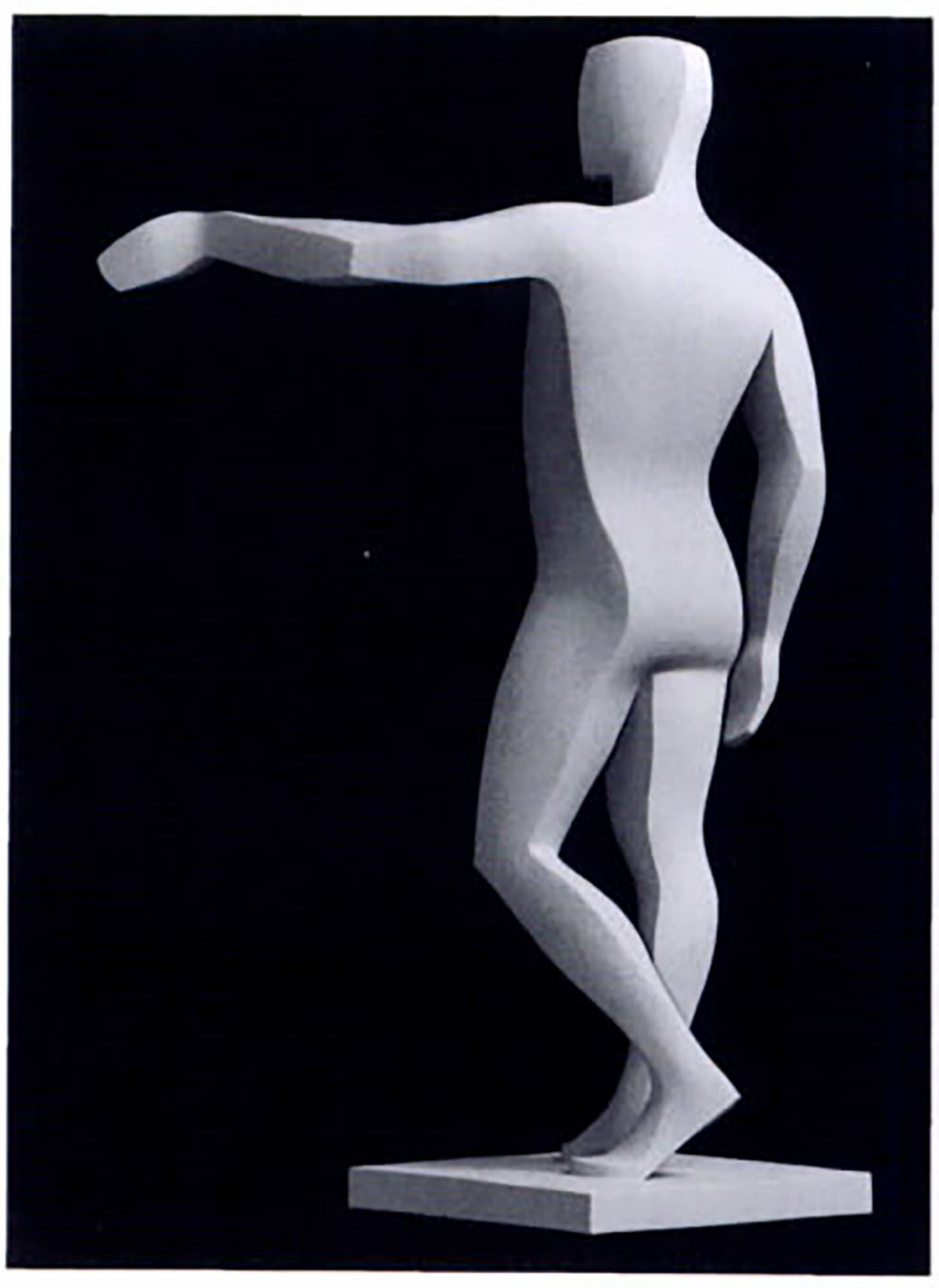
Blocks

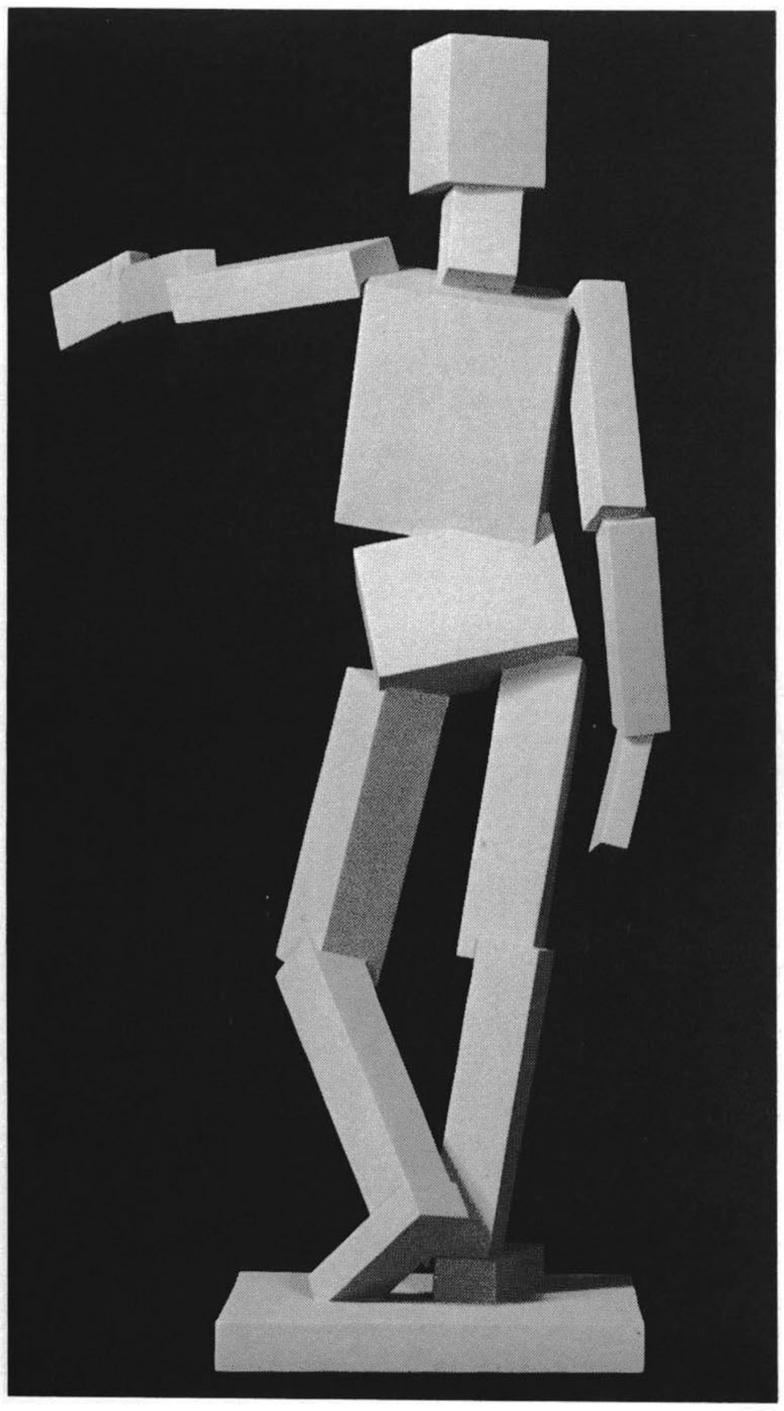


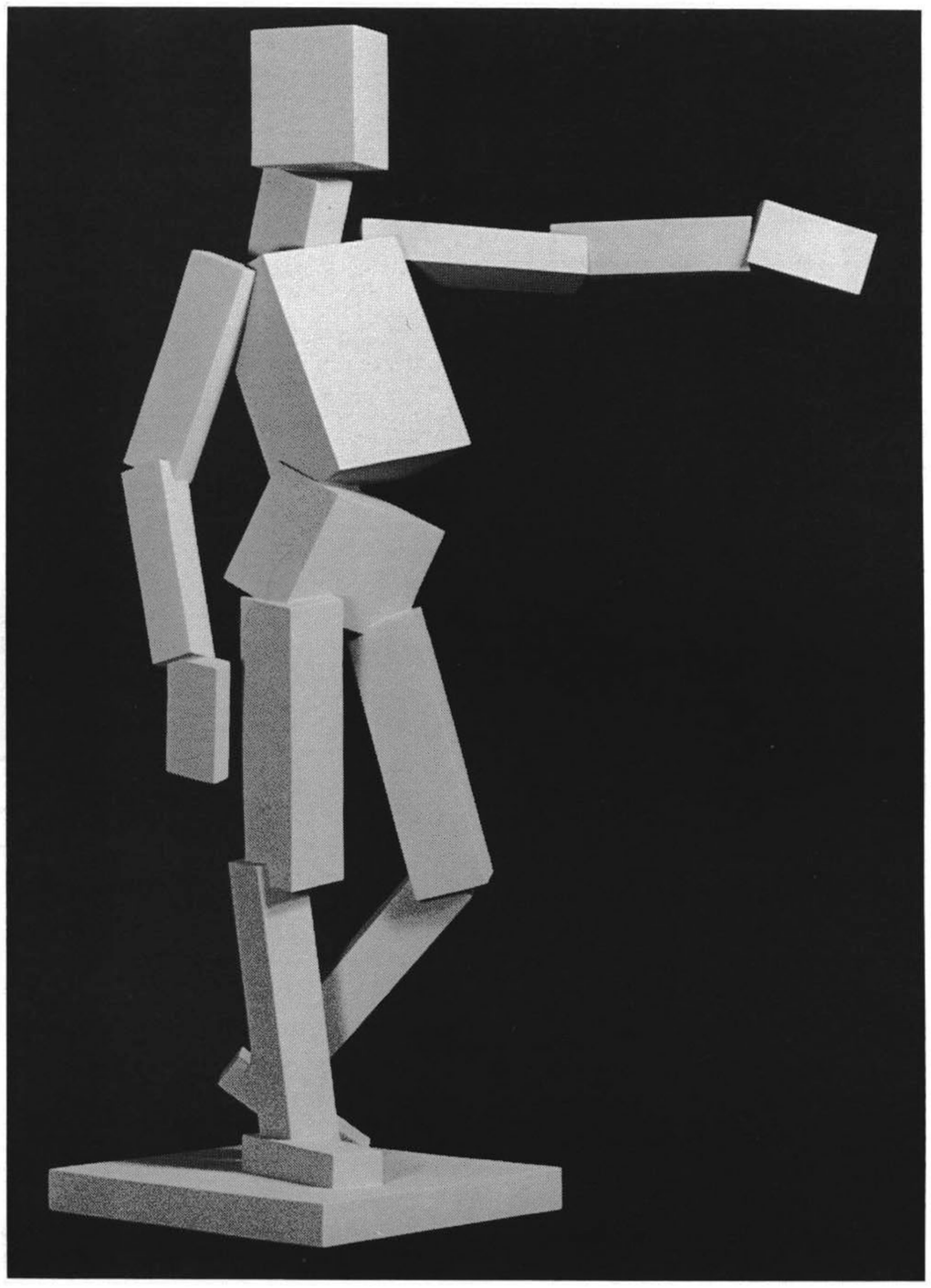


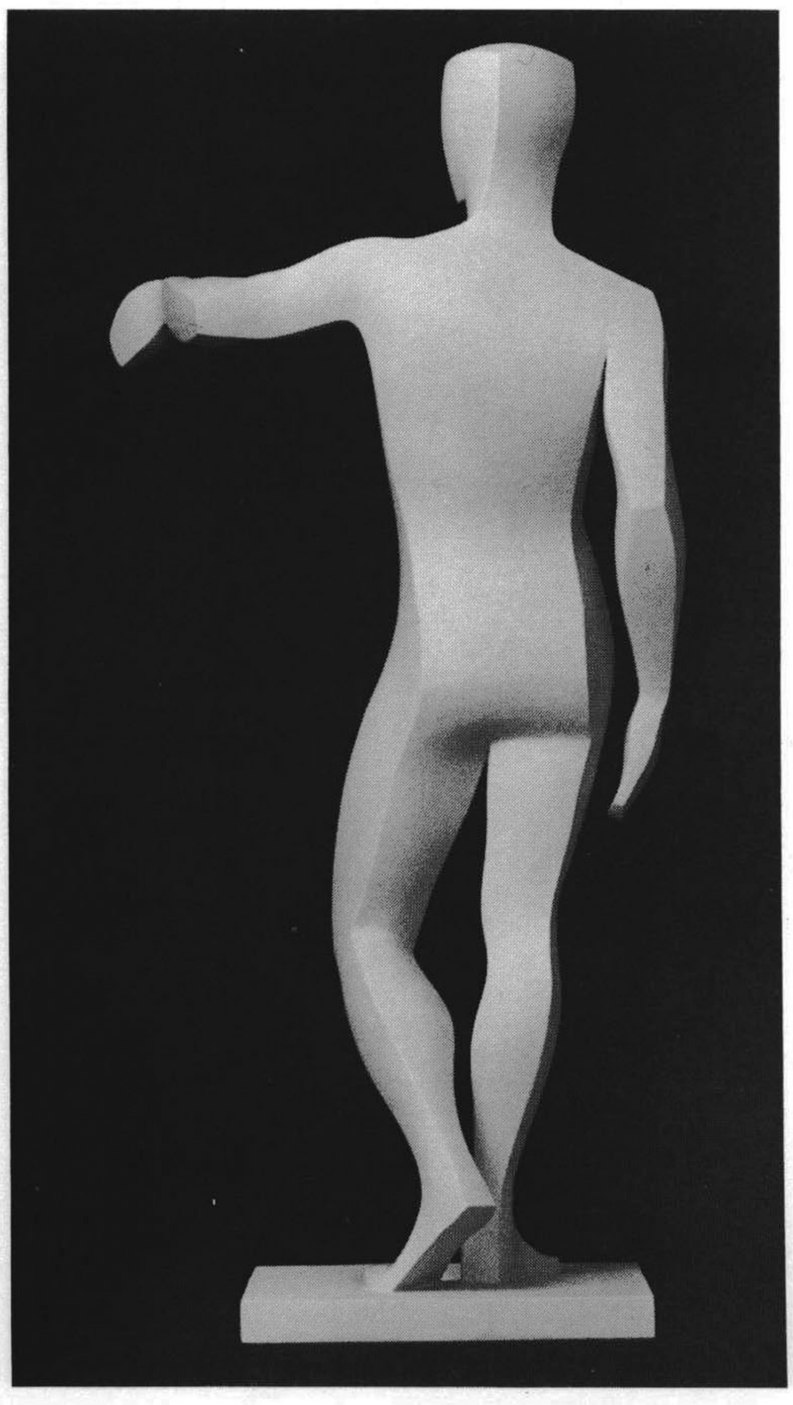
Continuous planes

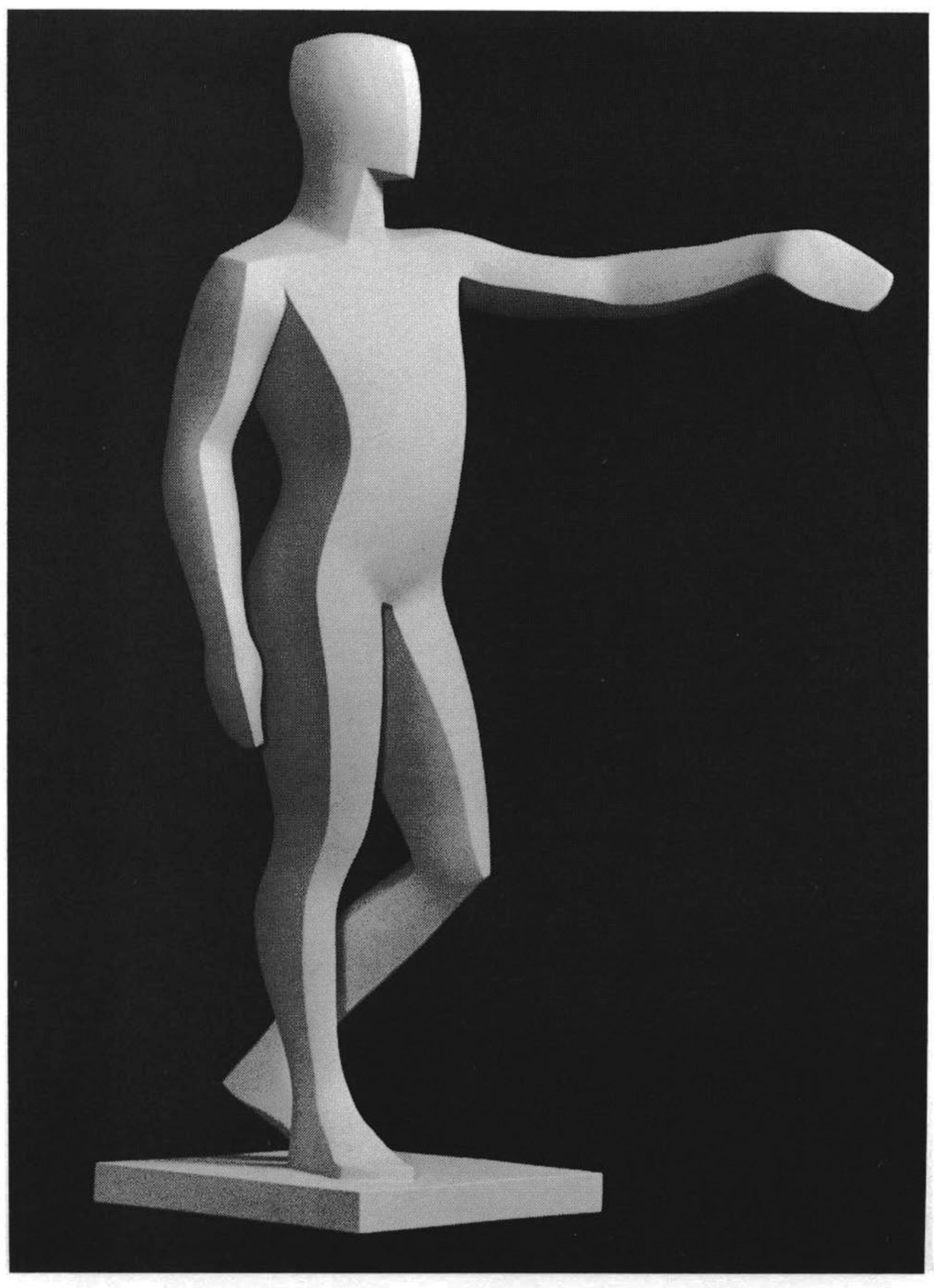




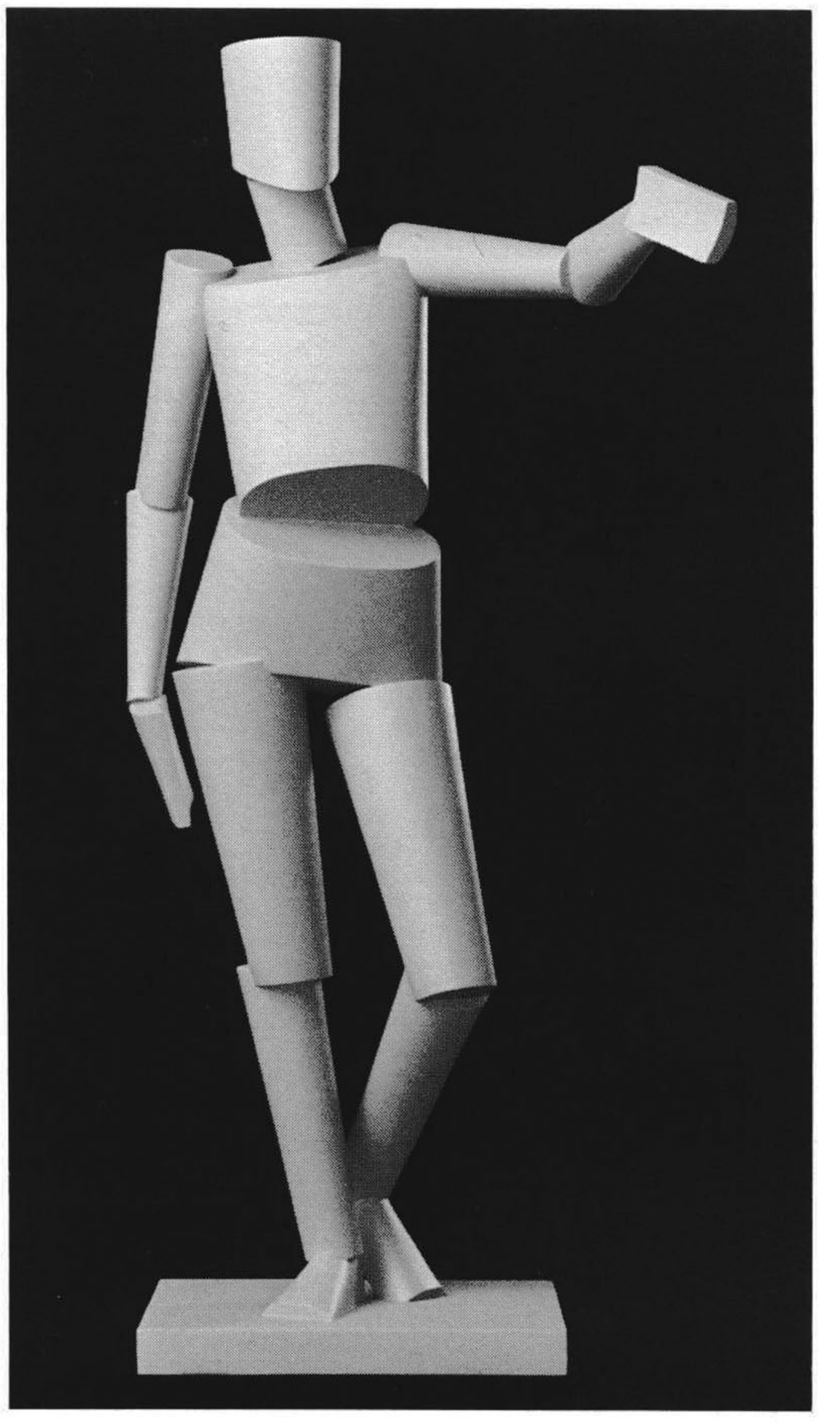


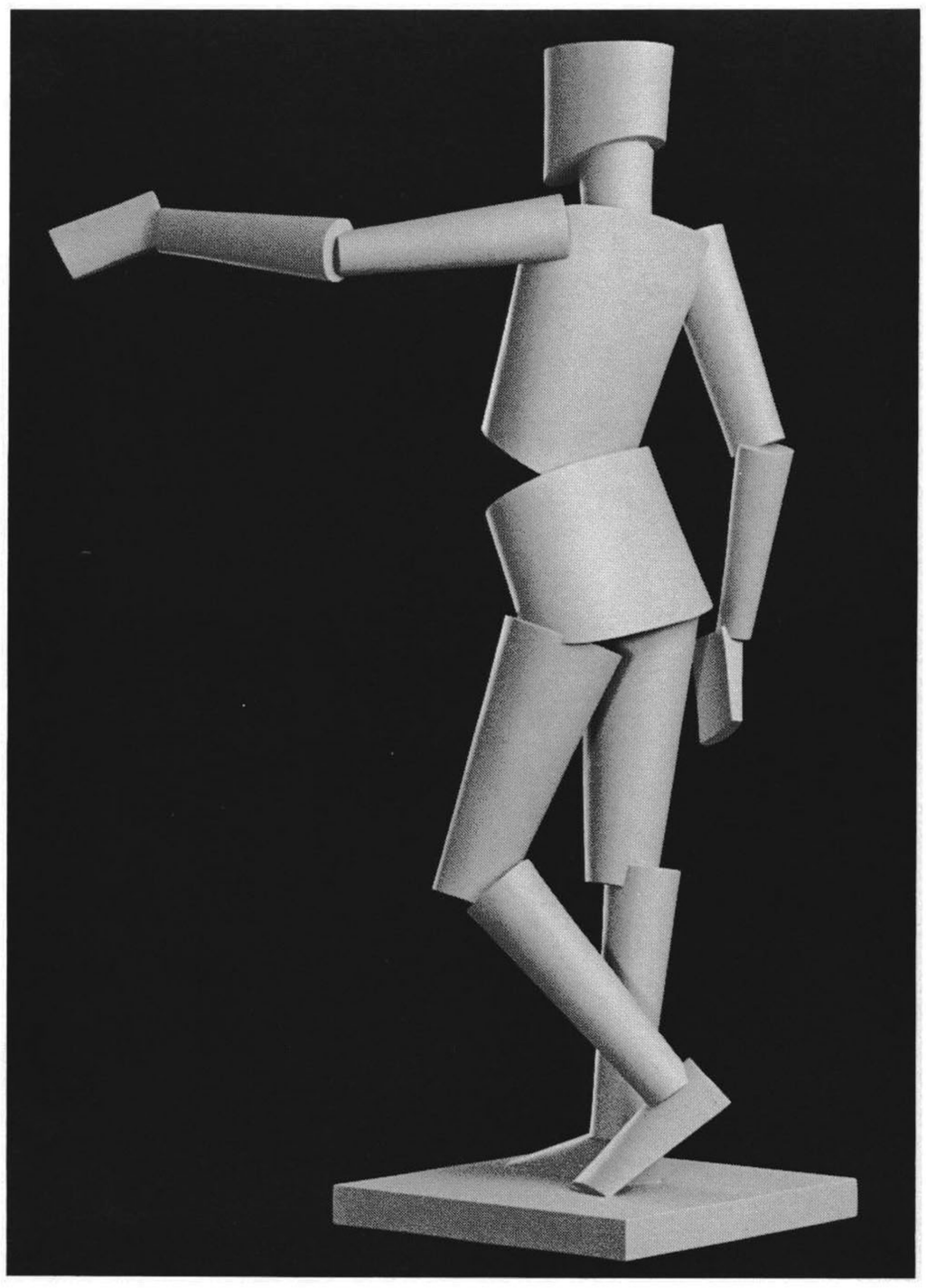




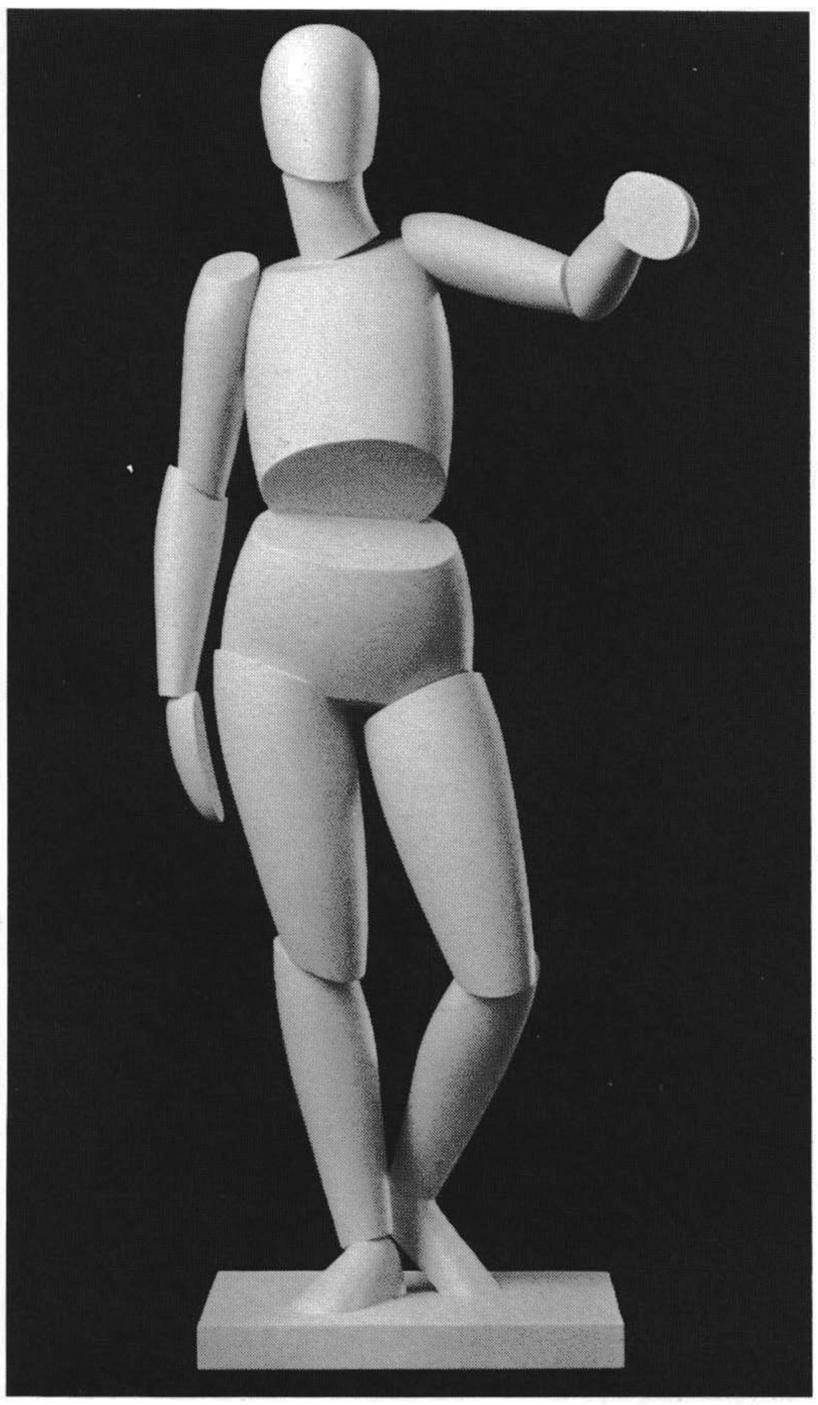


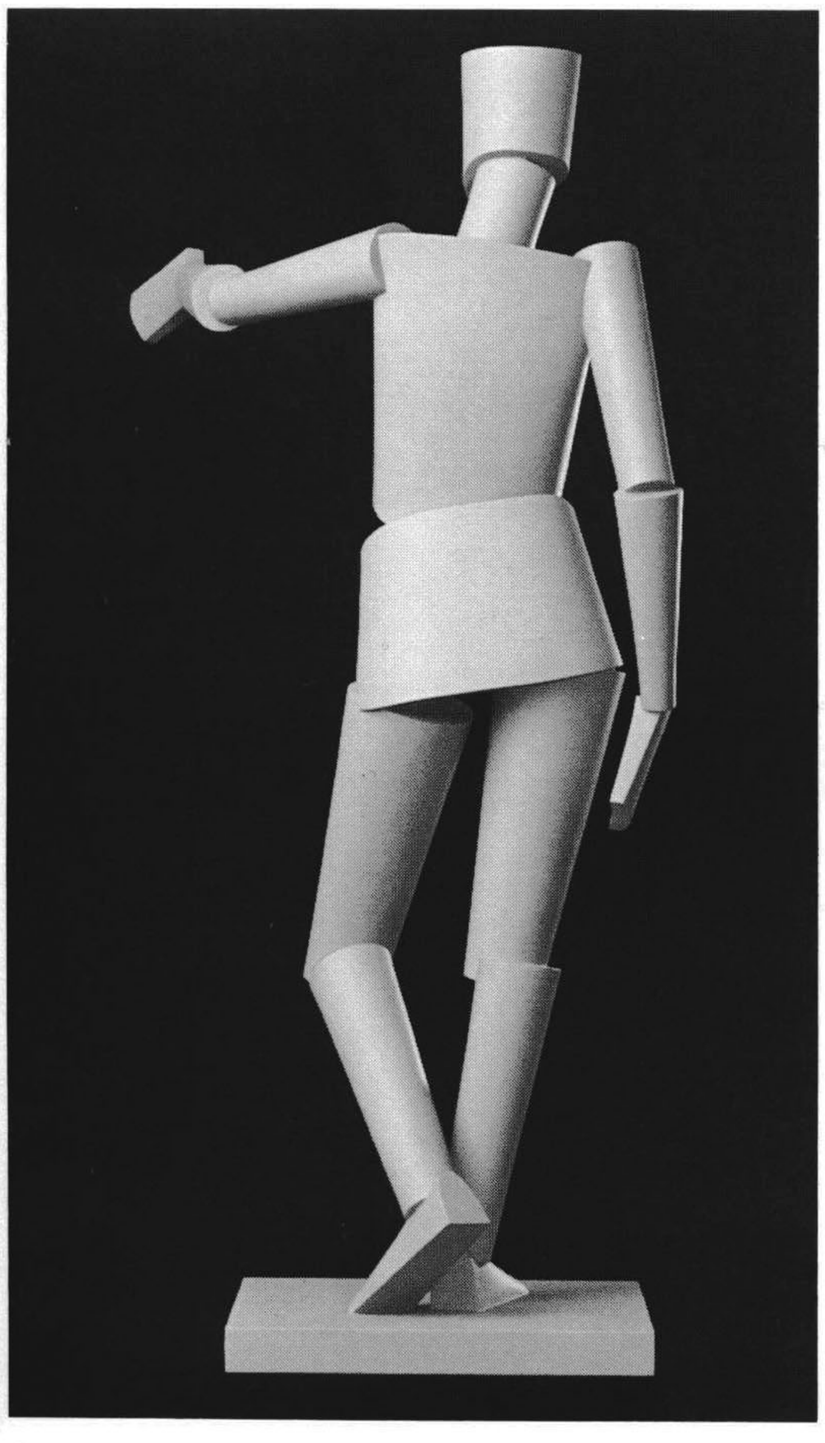
Tapered cylinders (cones)

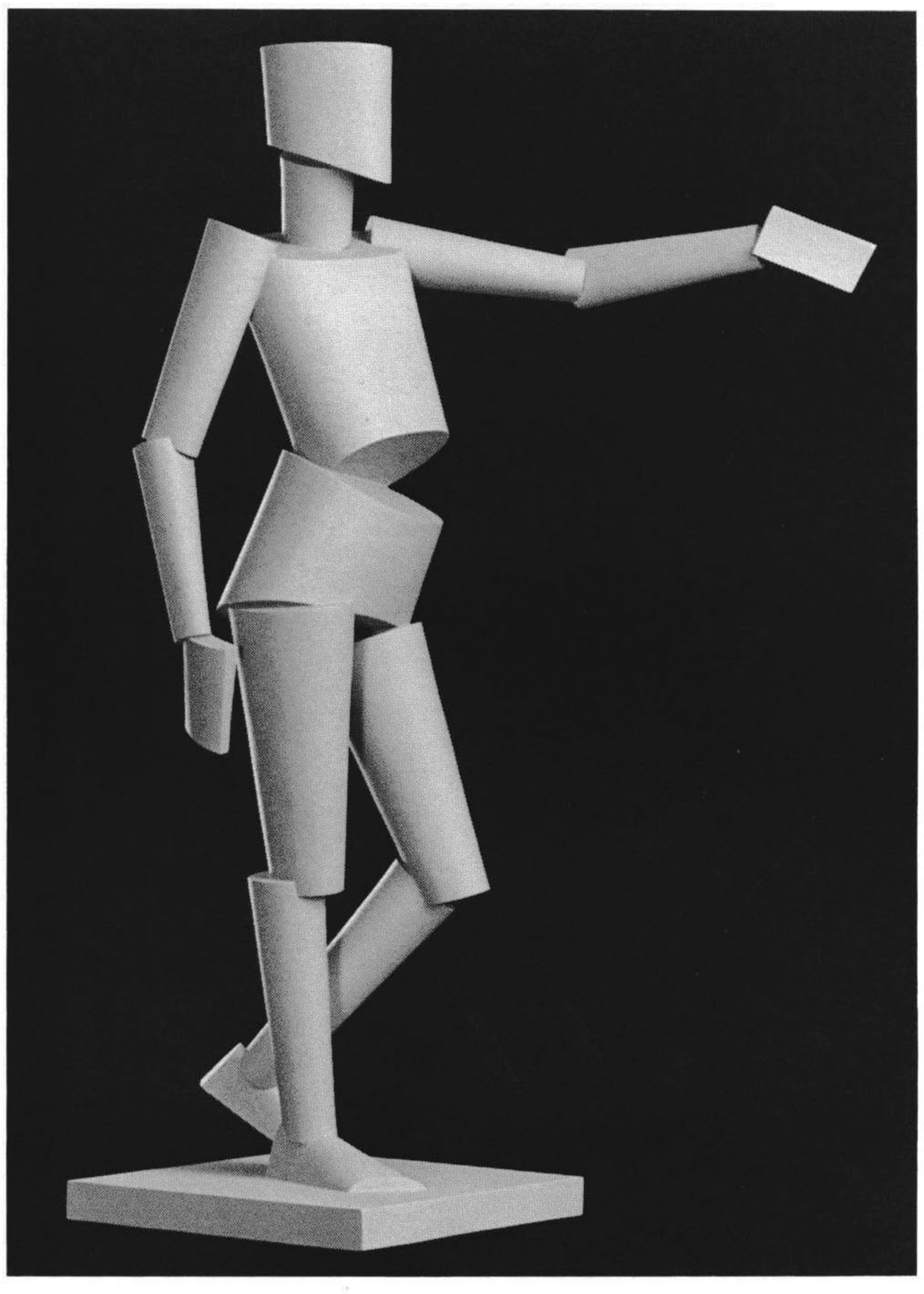


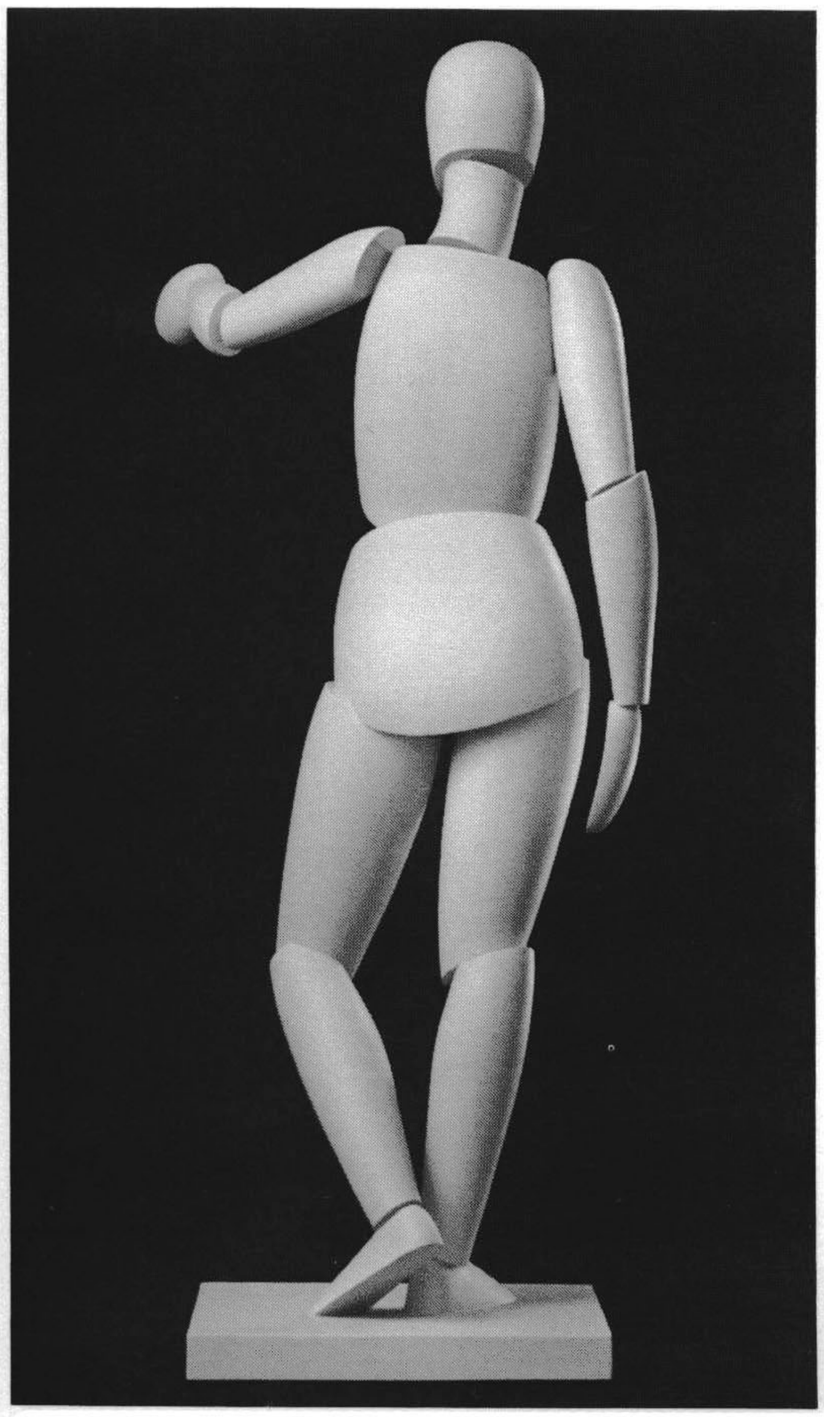


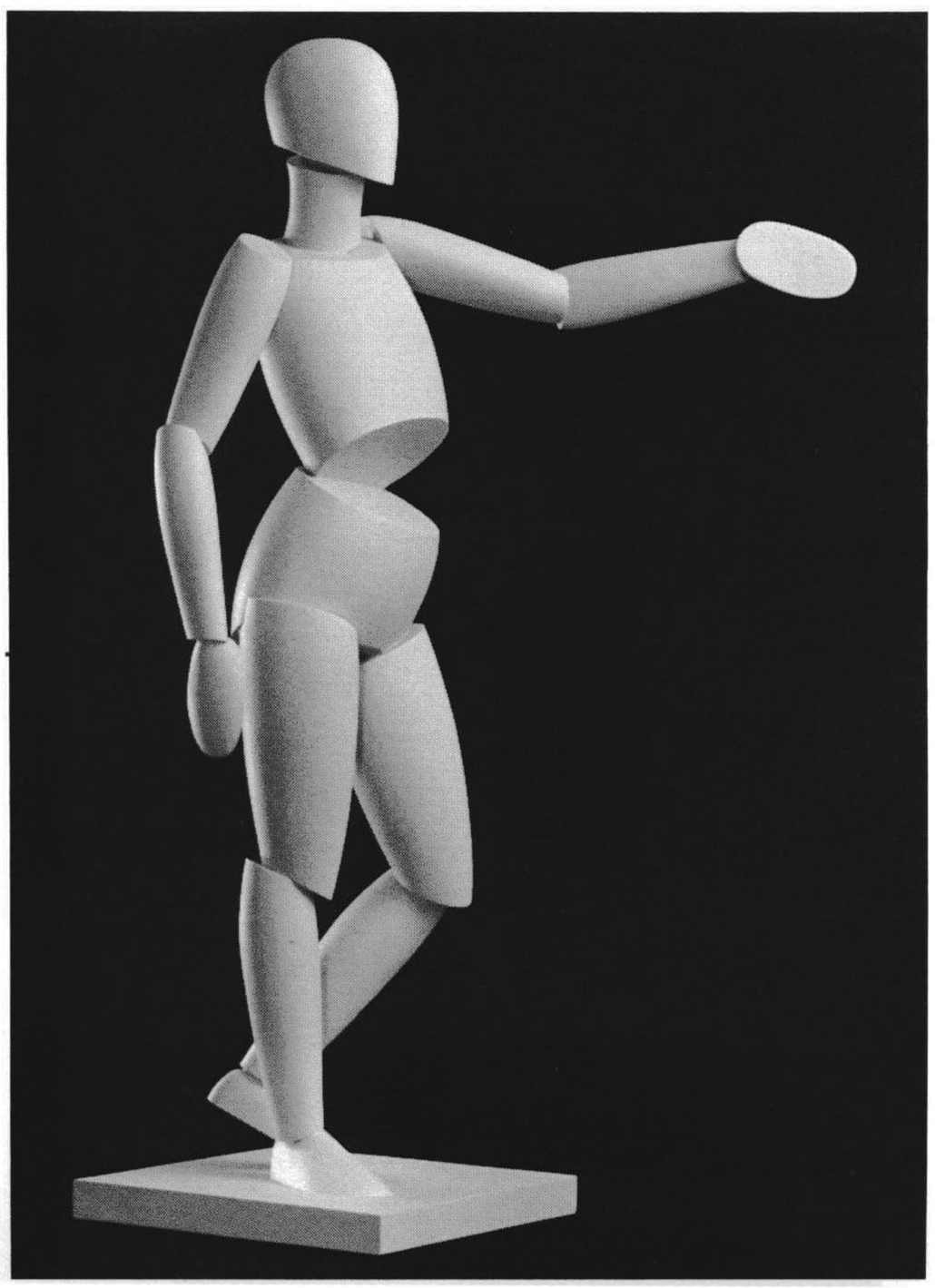
Ovoids





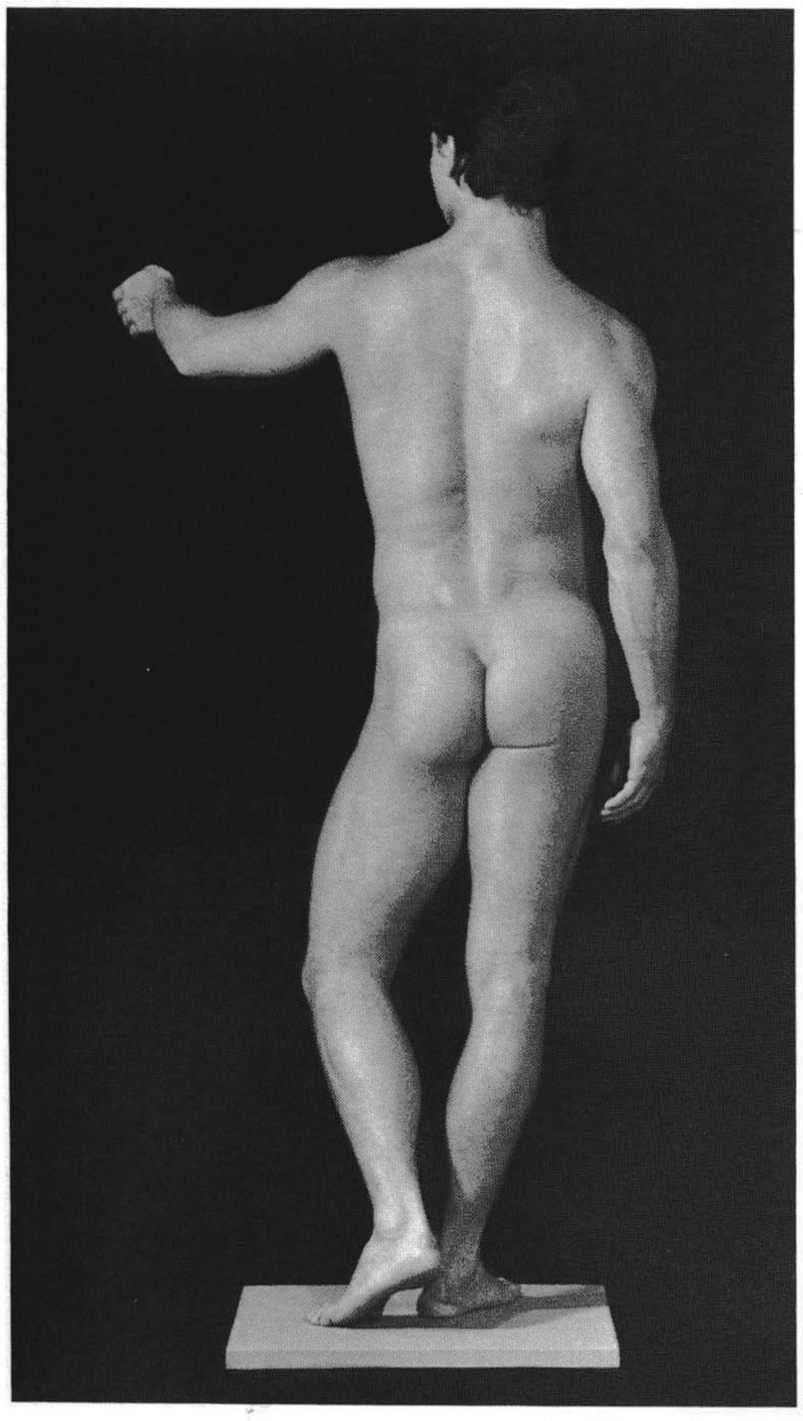


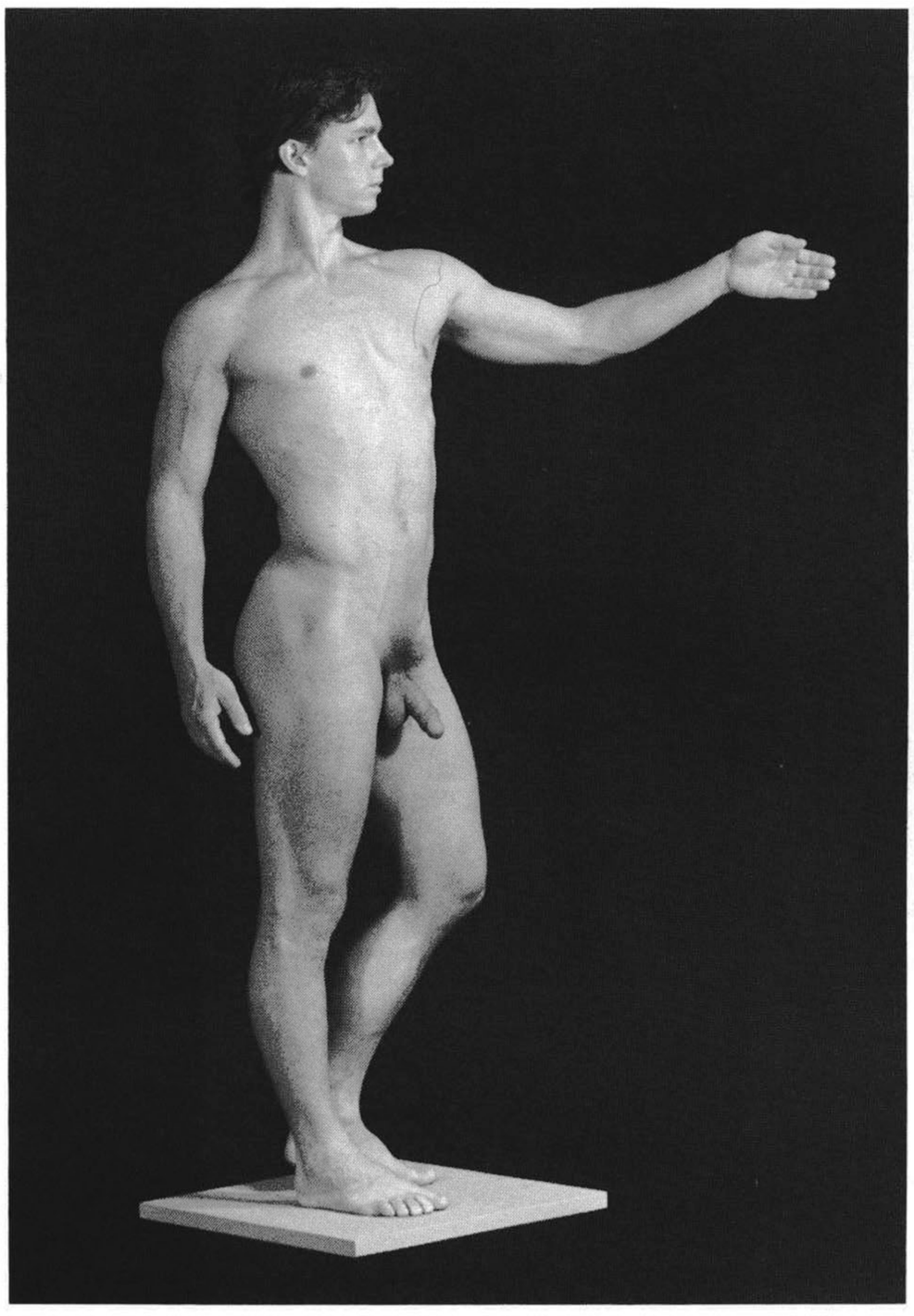


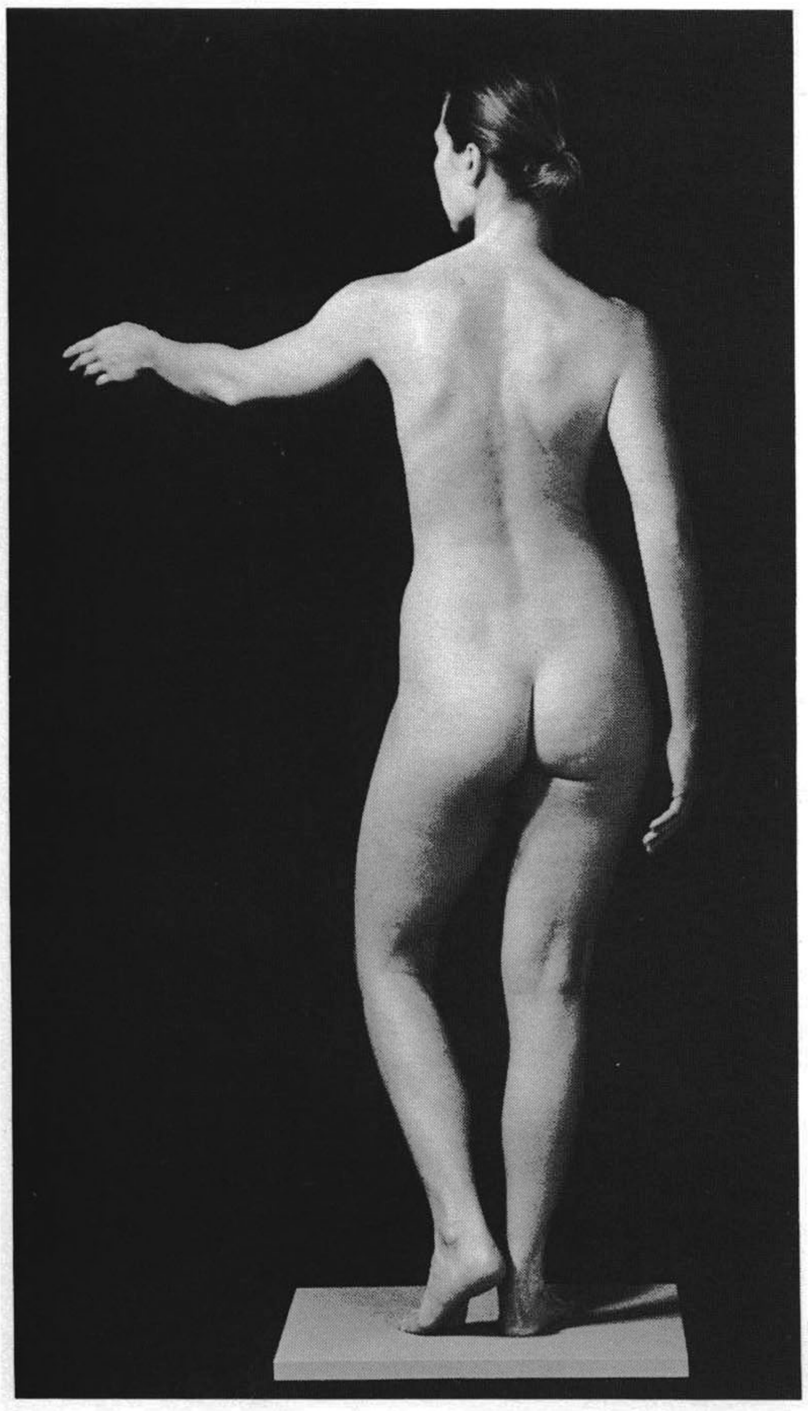


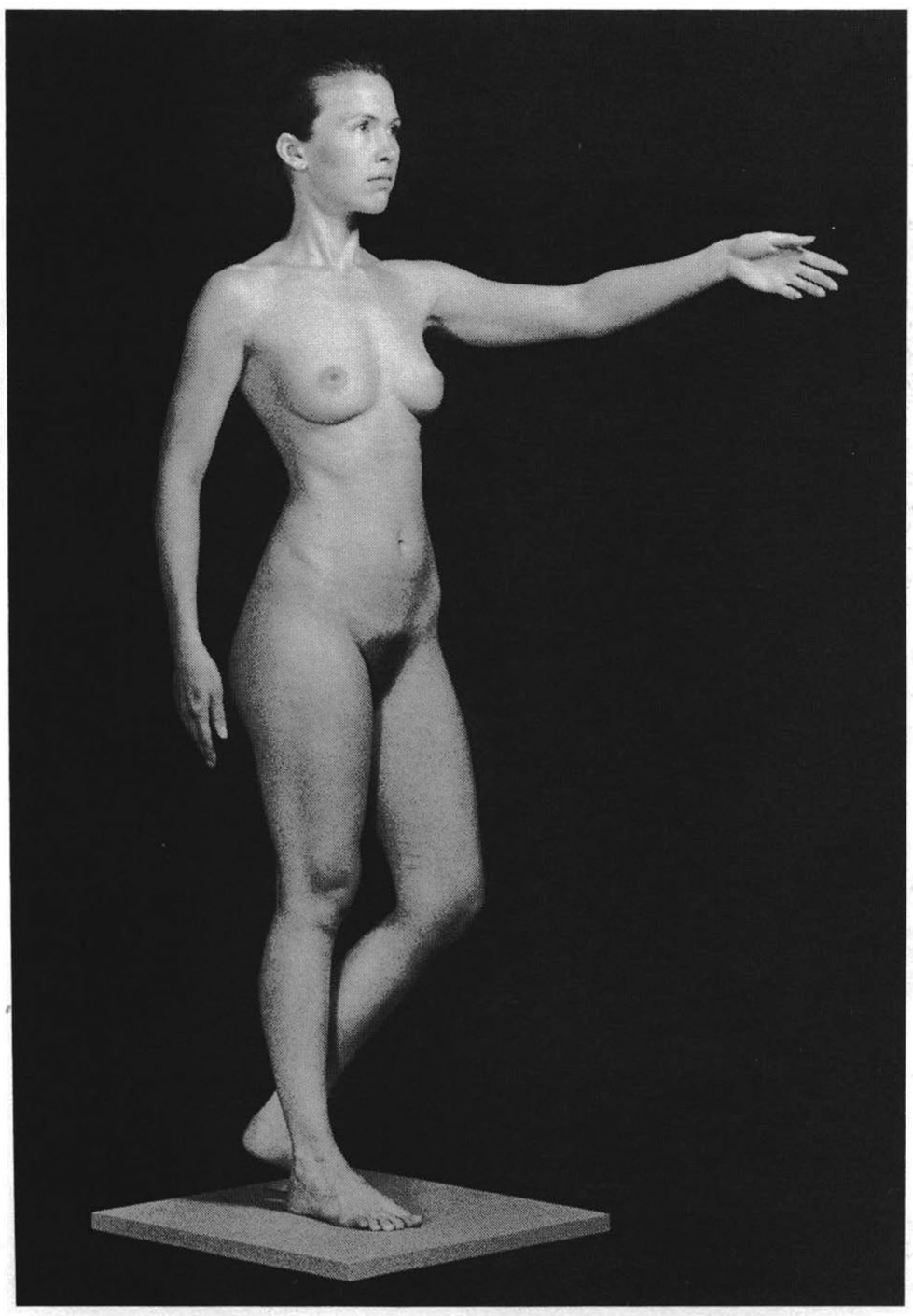
Male—life

Female—life









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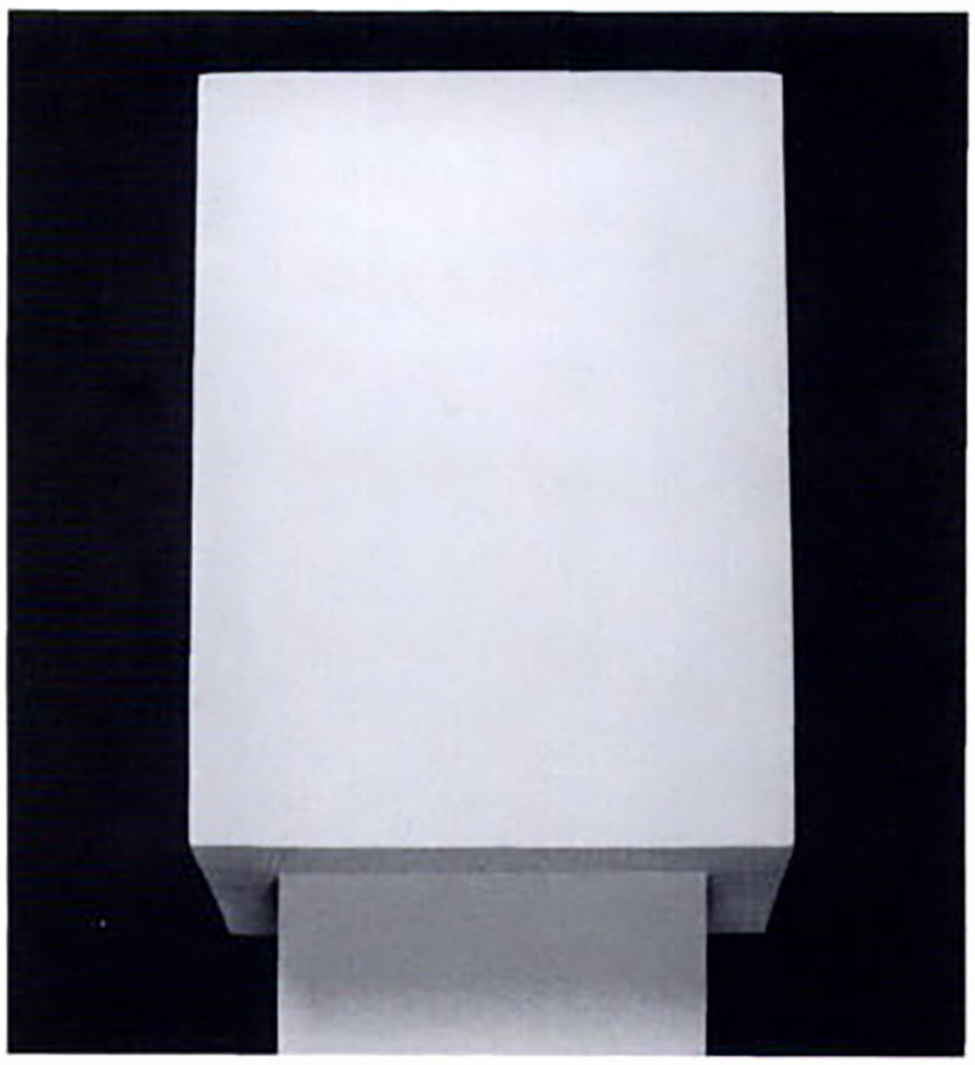
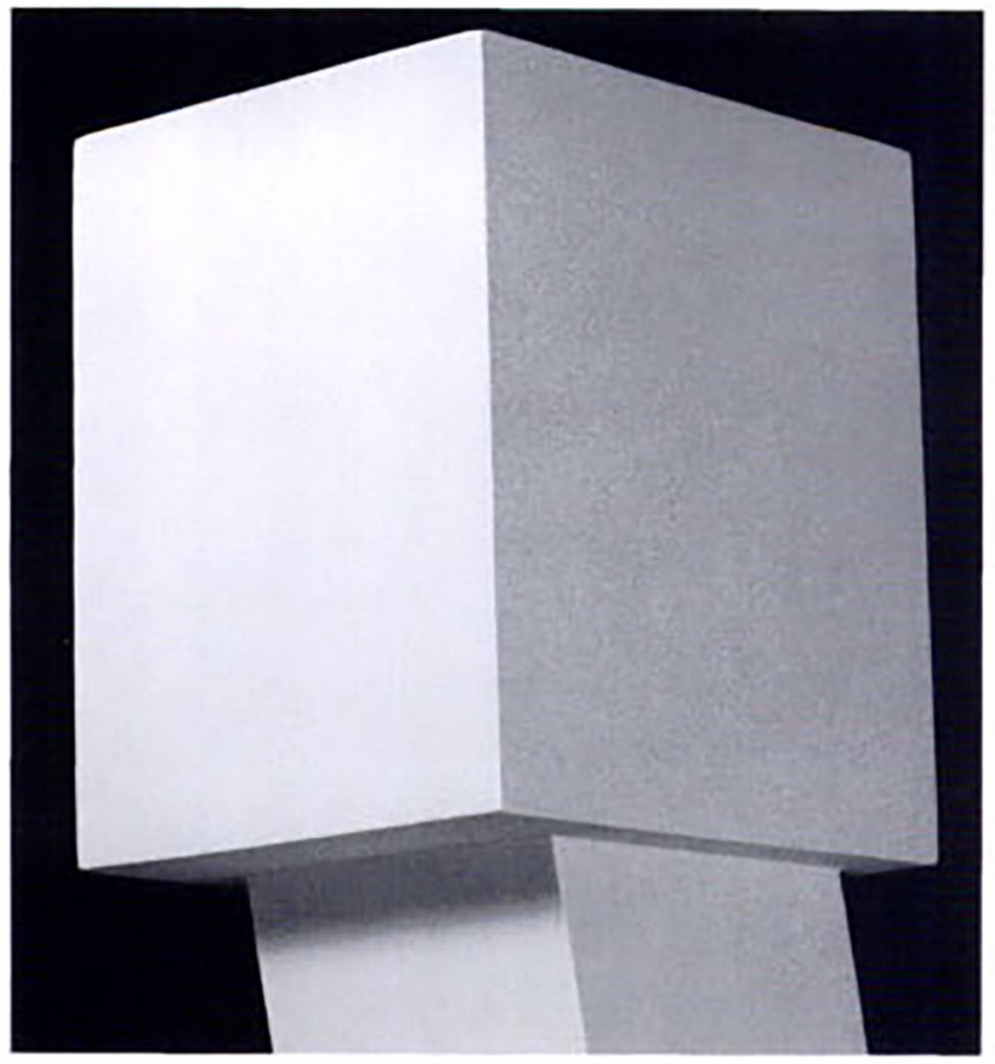
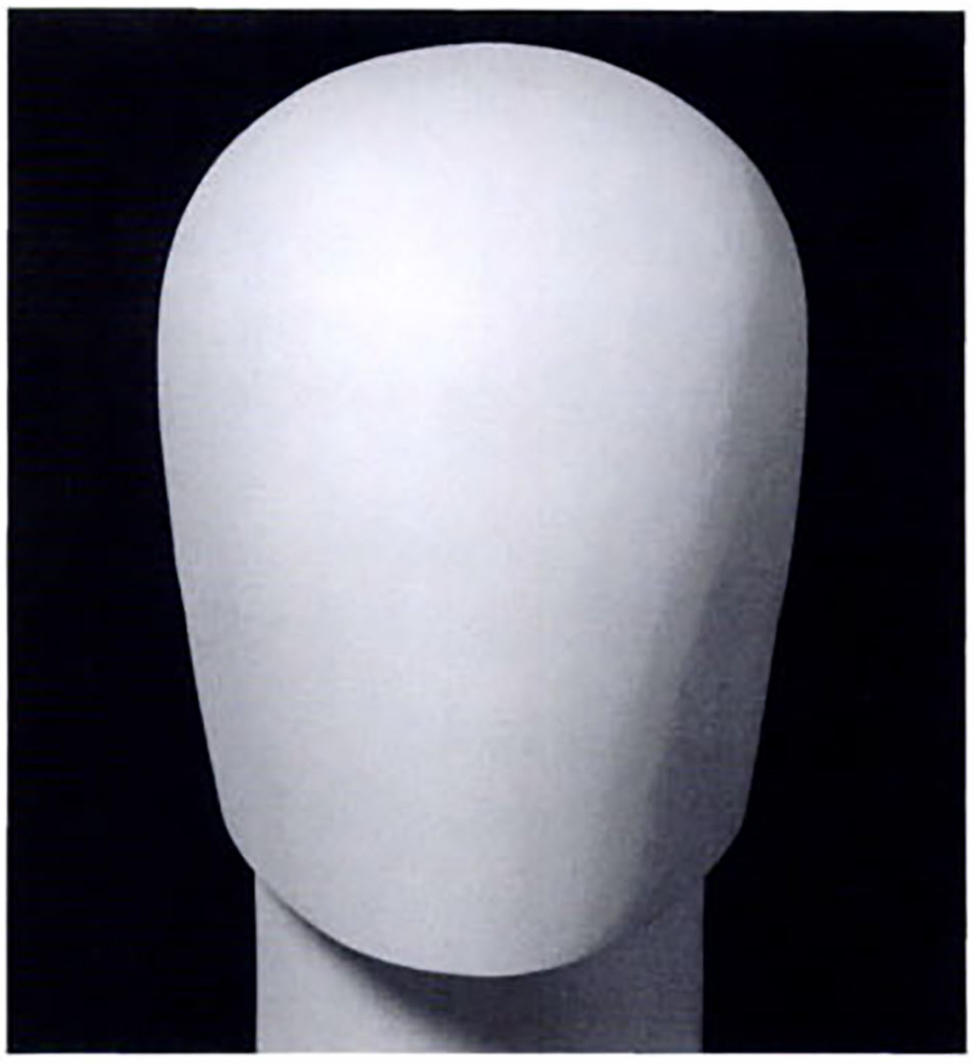
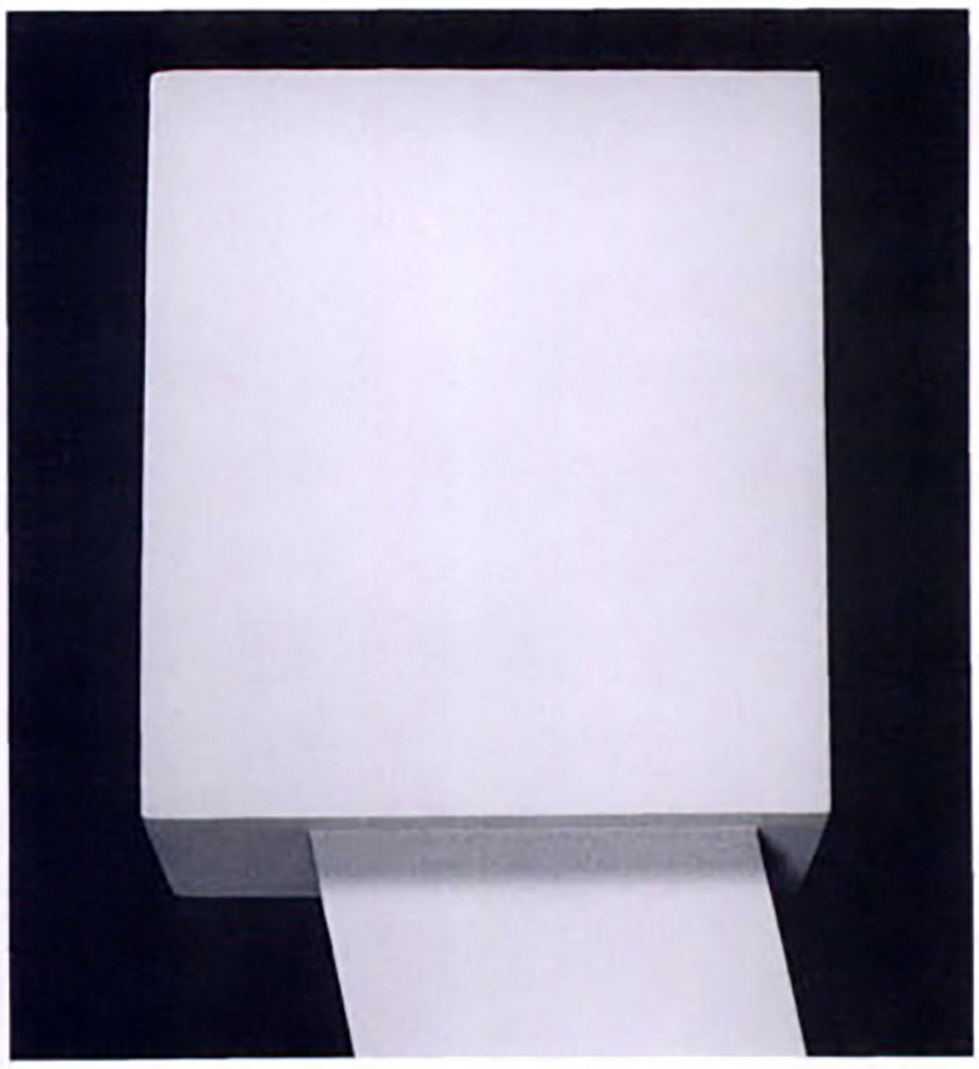
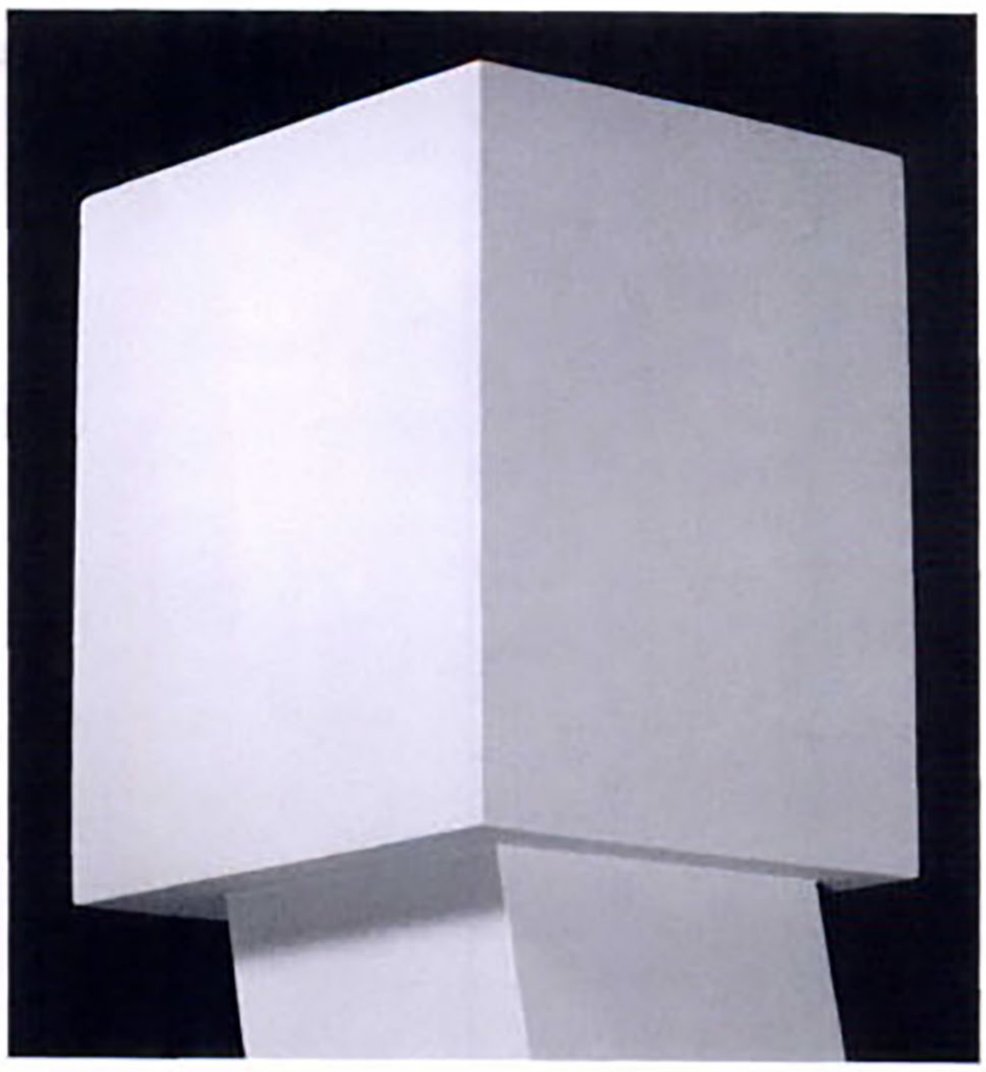




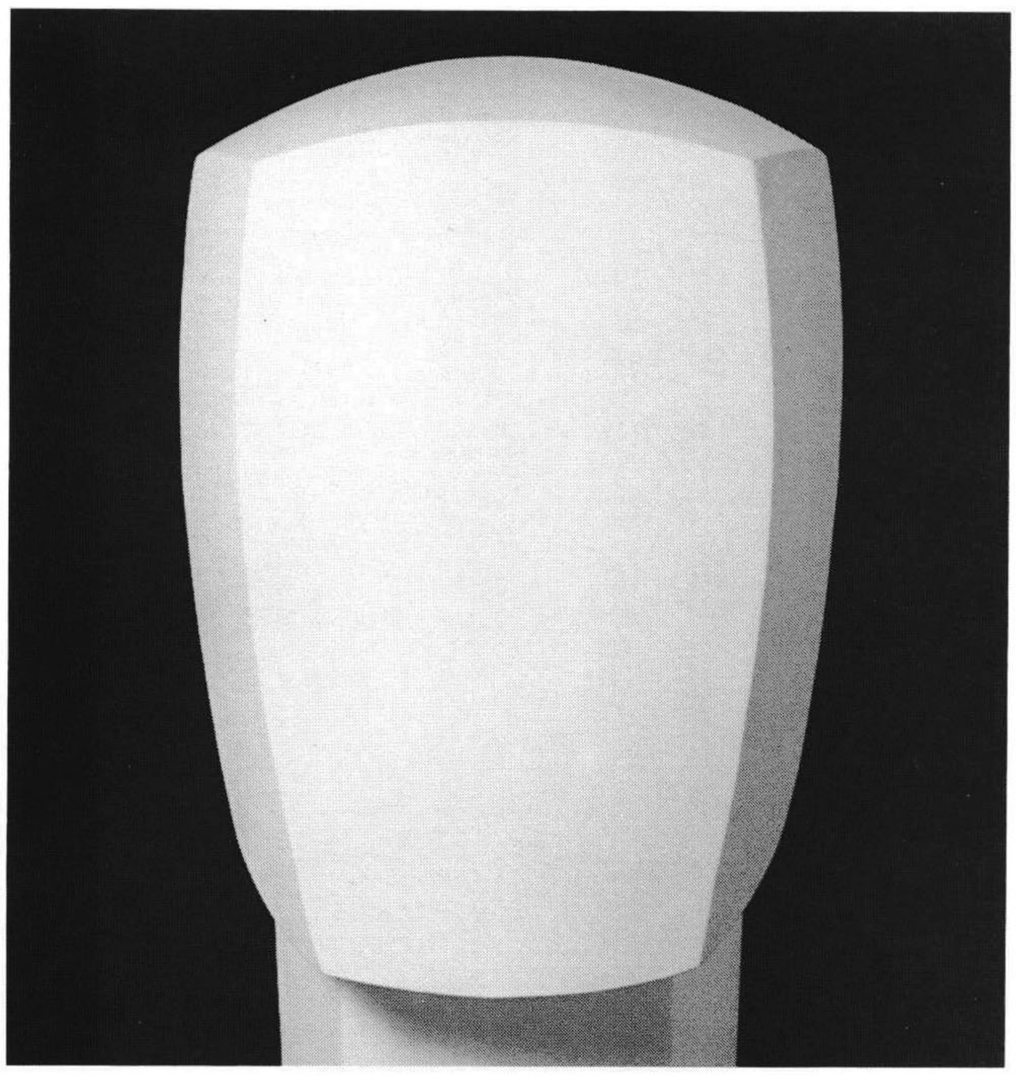
Rounded form

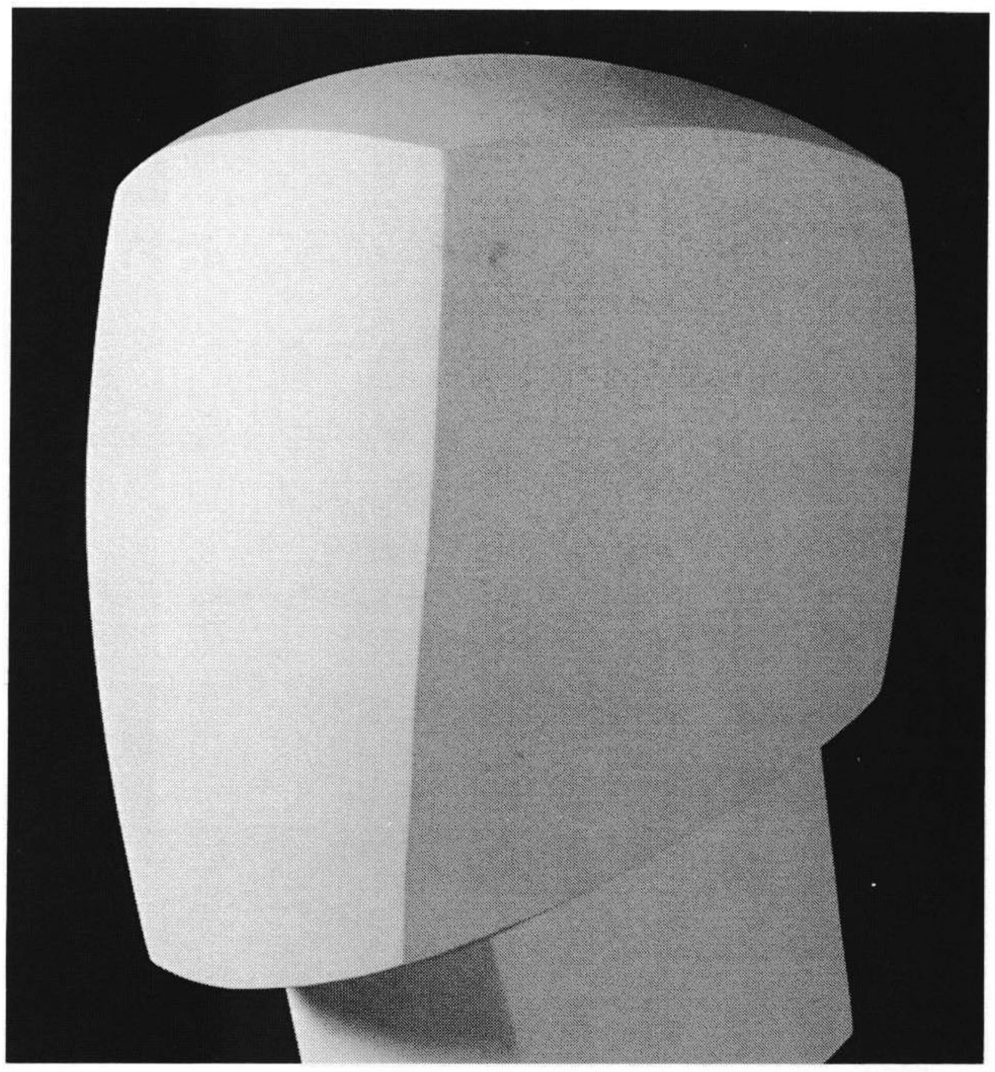




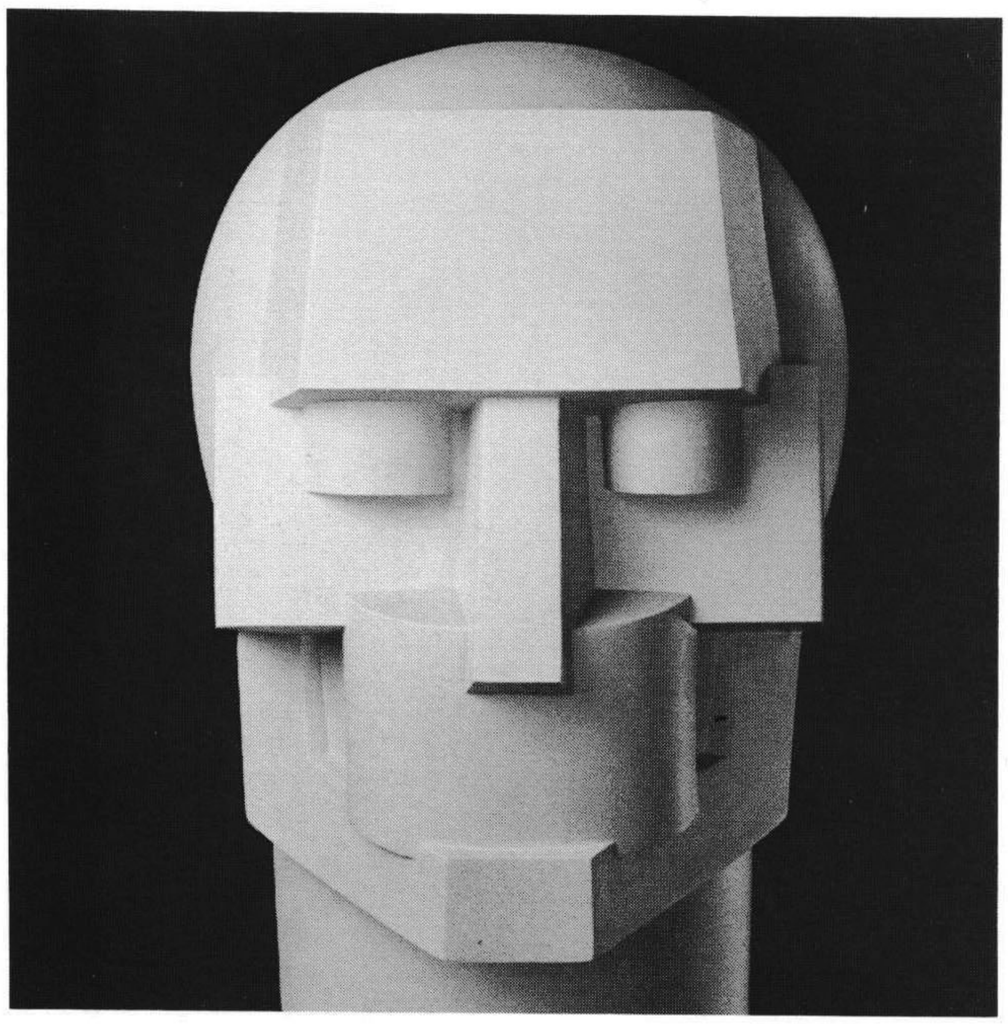


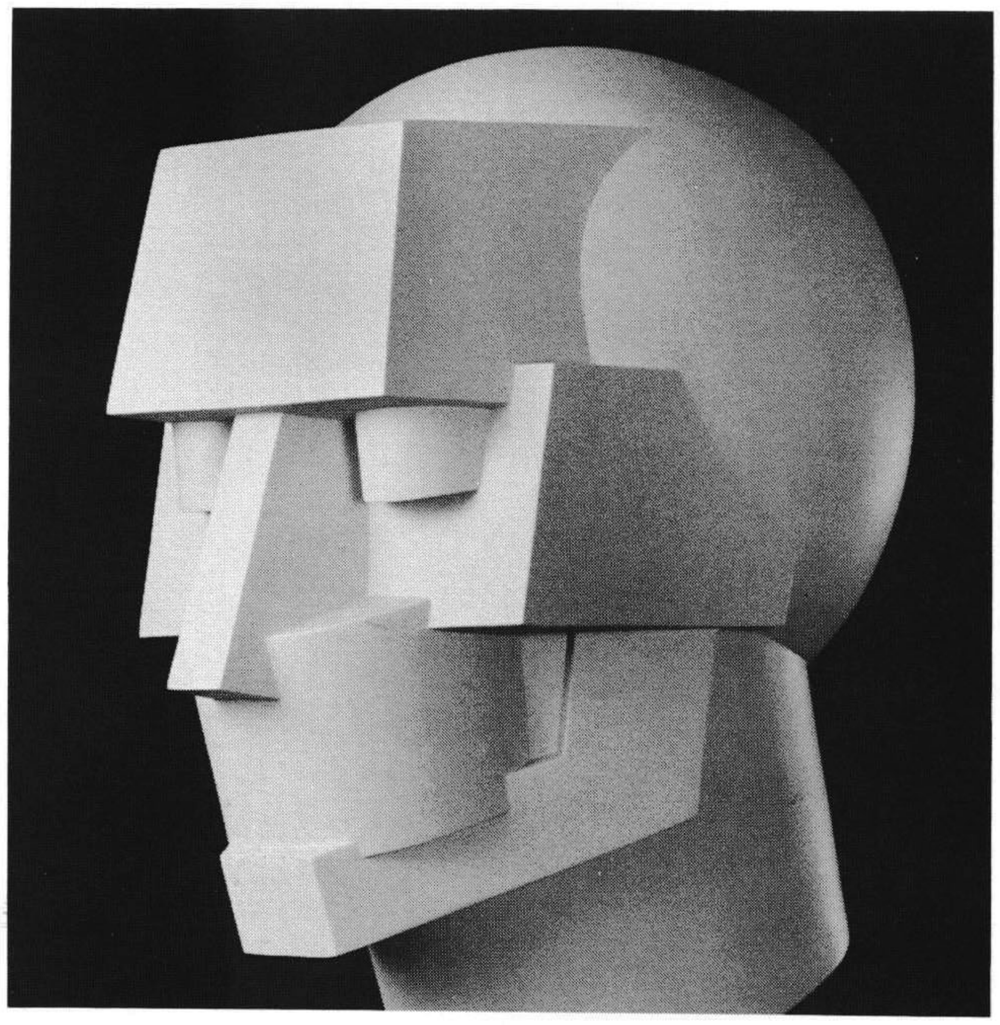
Single rounded planes

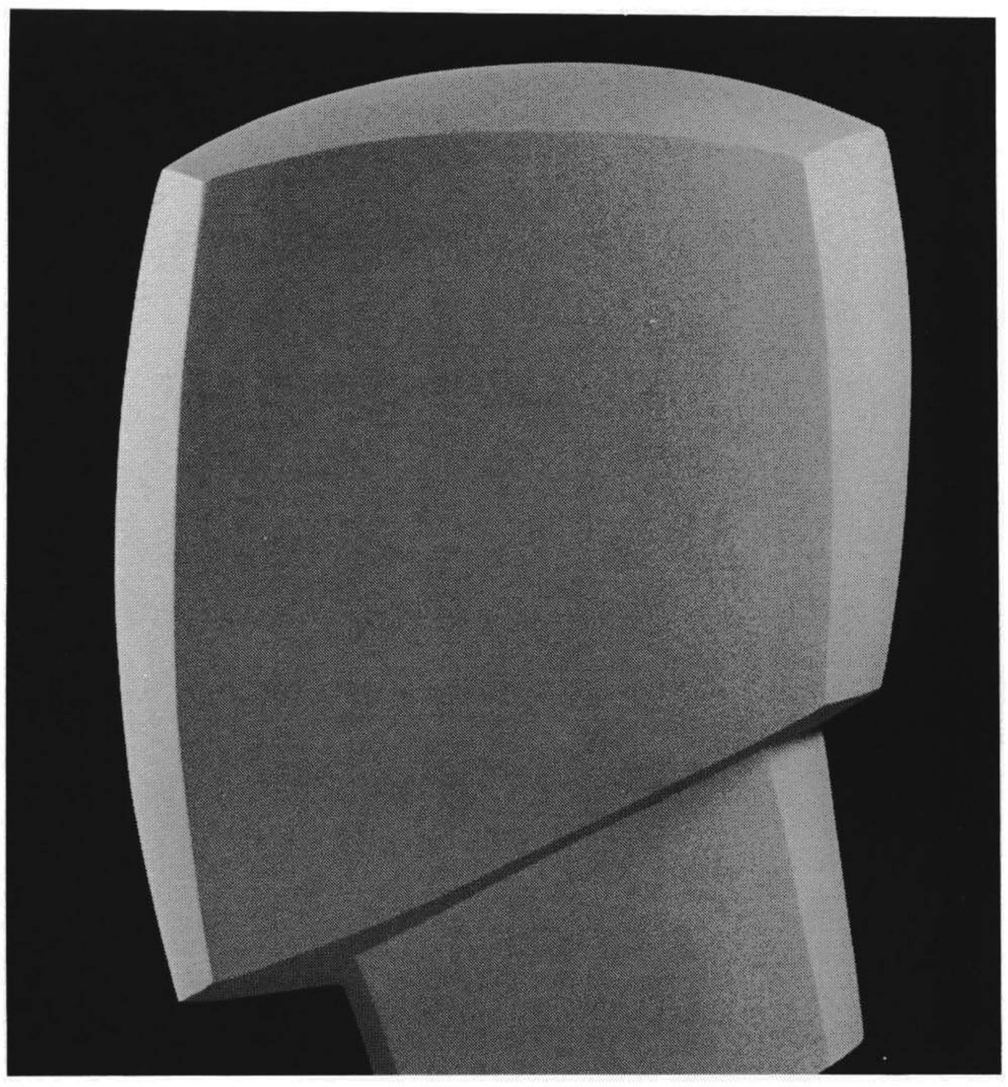


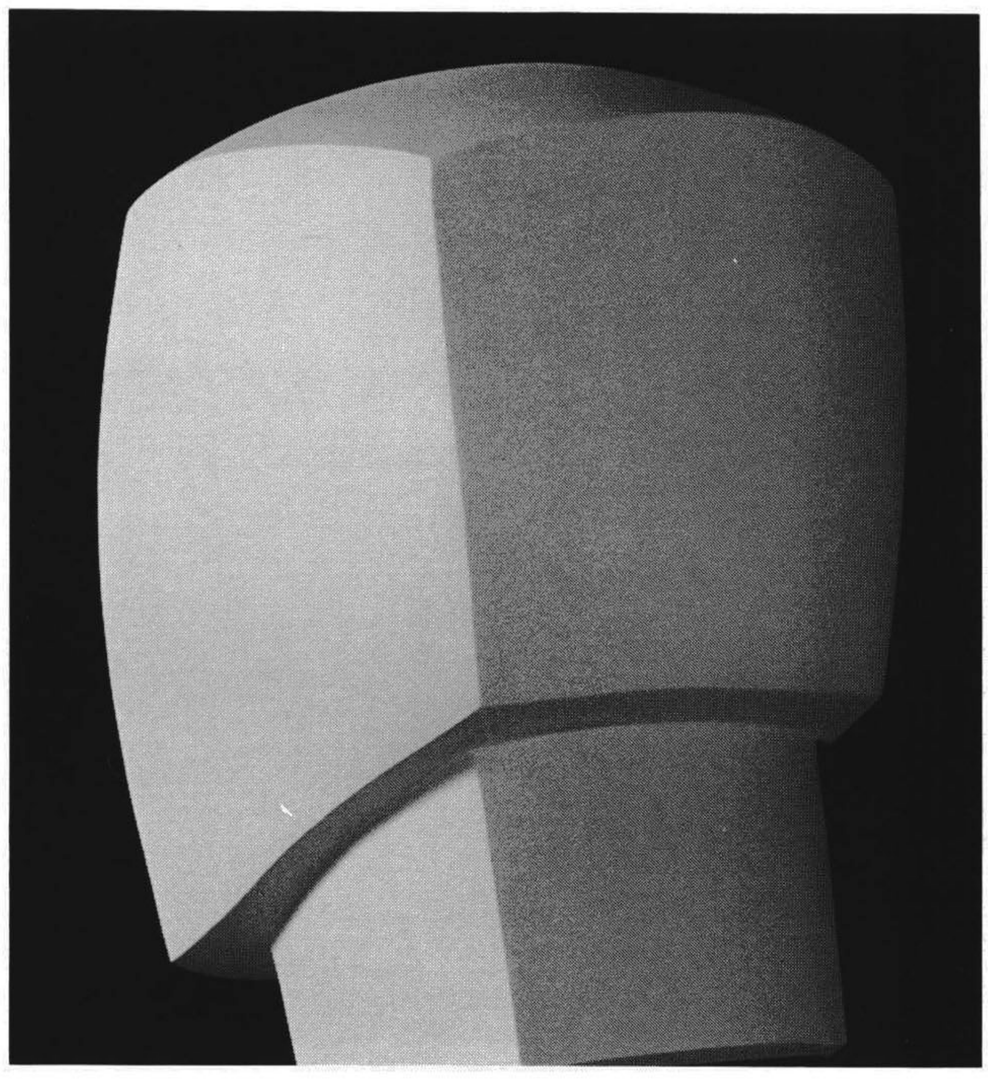


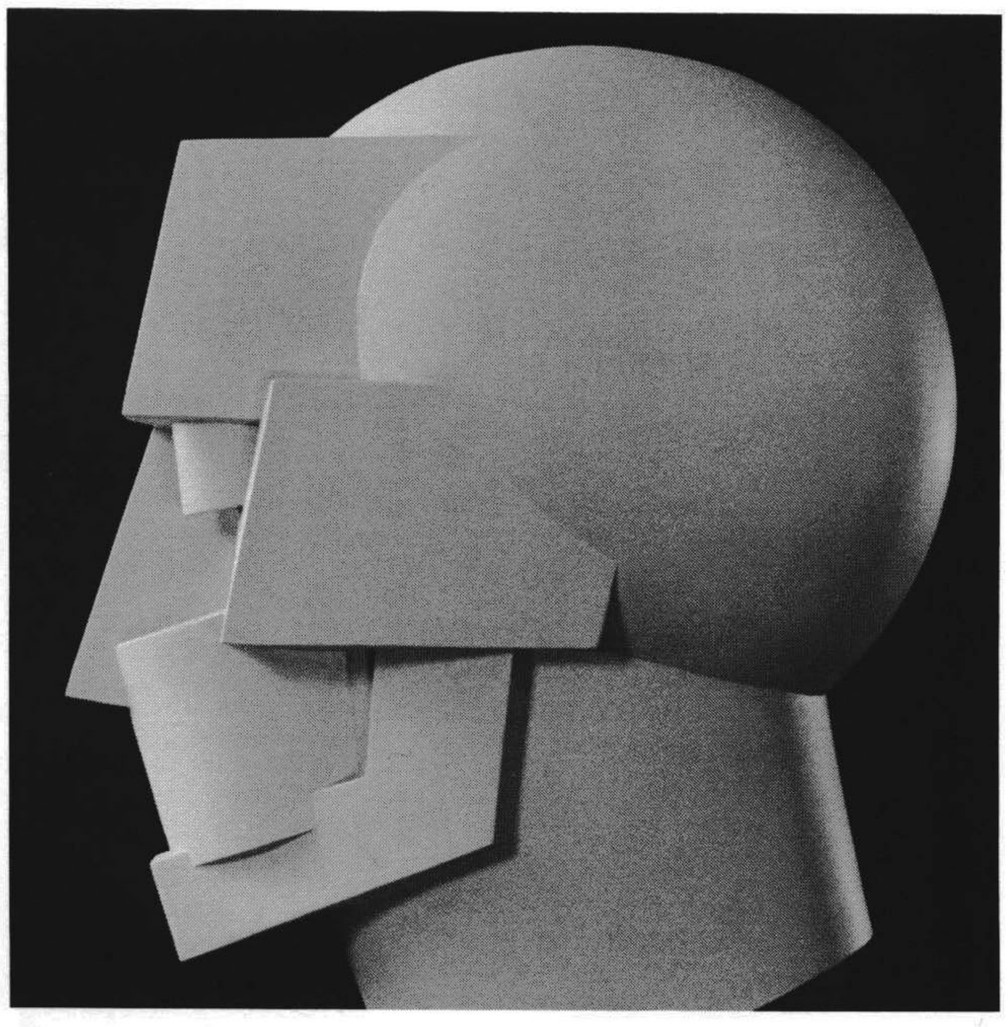
Underlying volumes

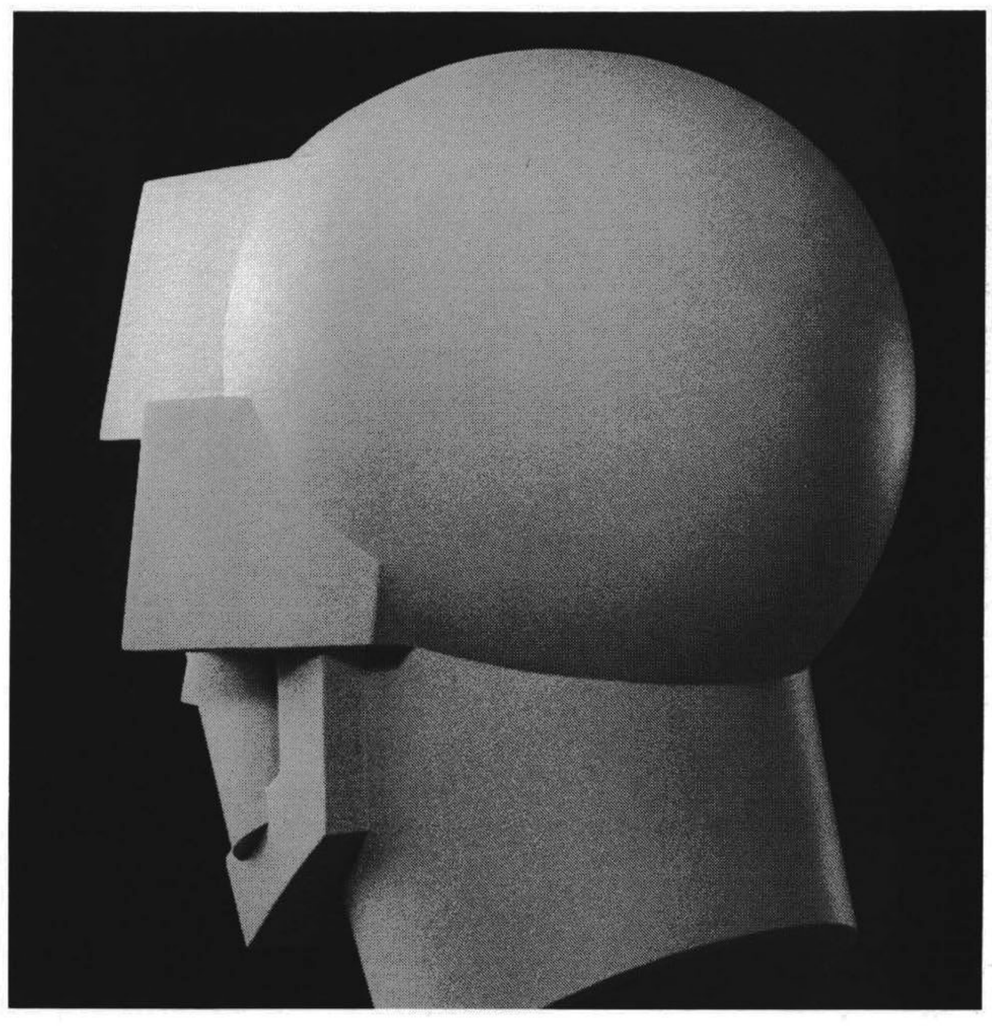




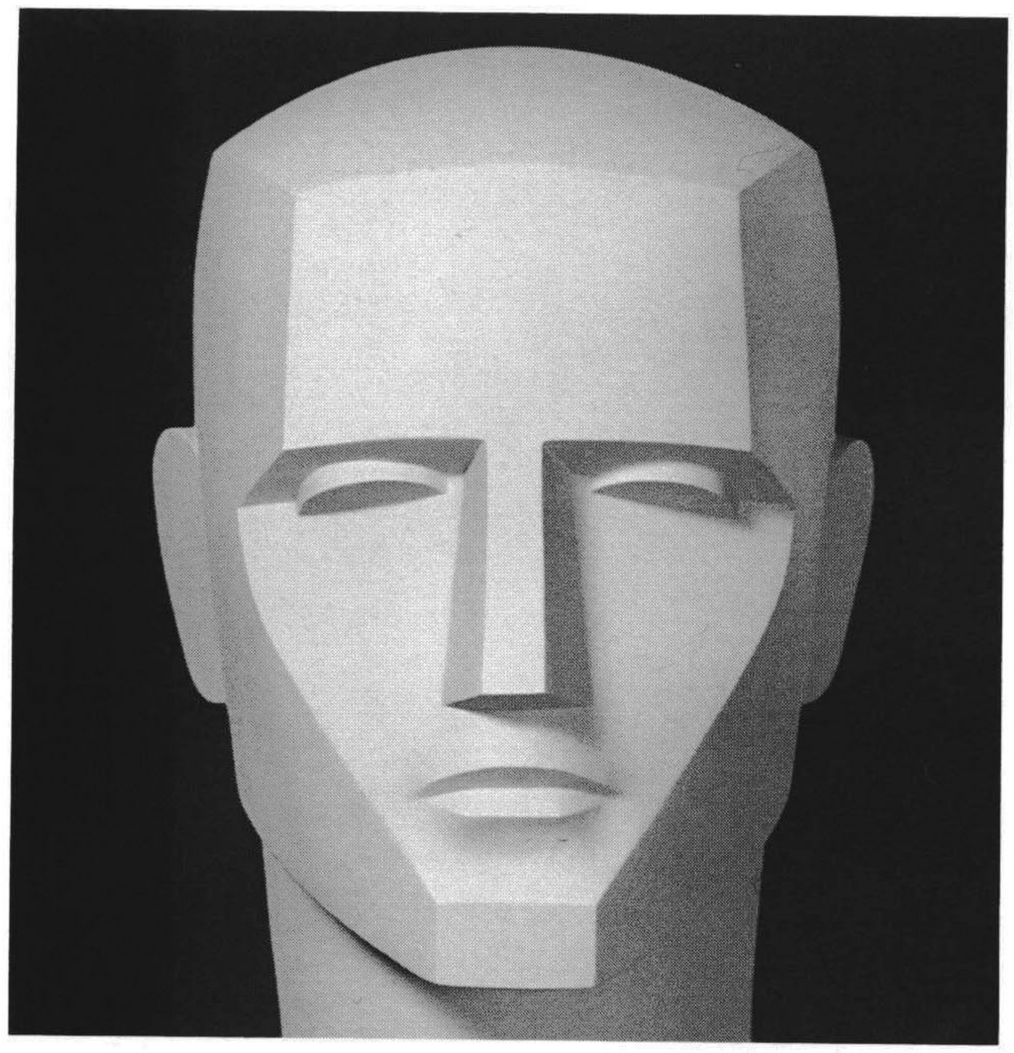


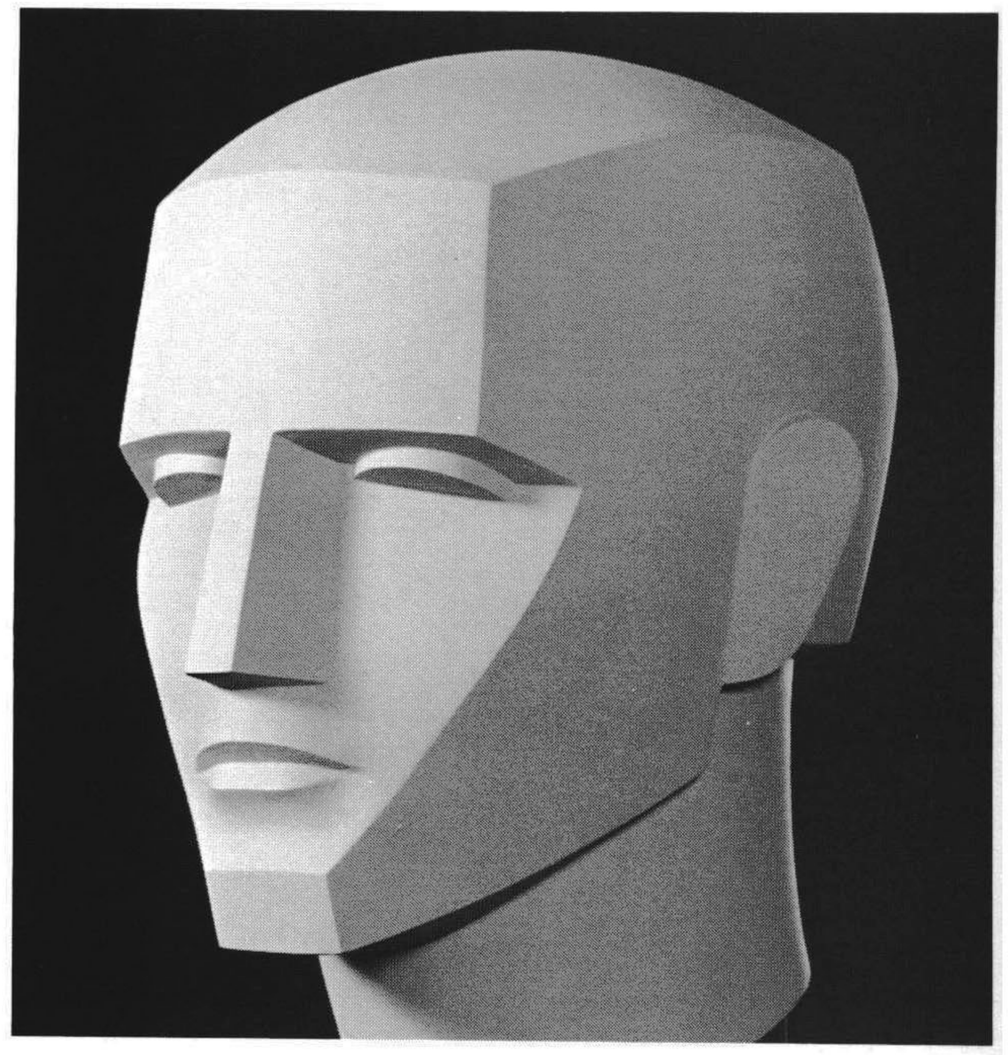




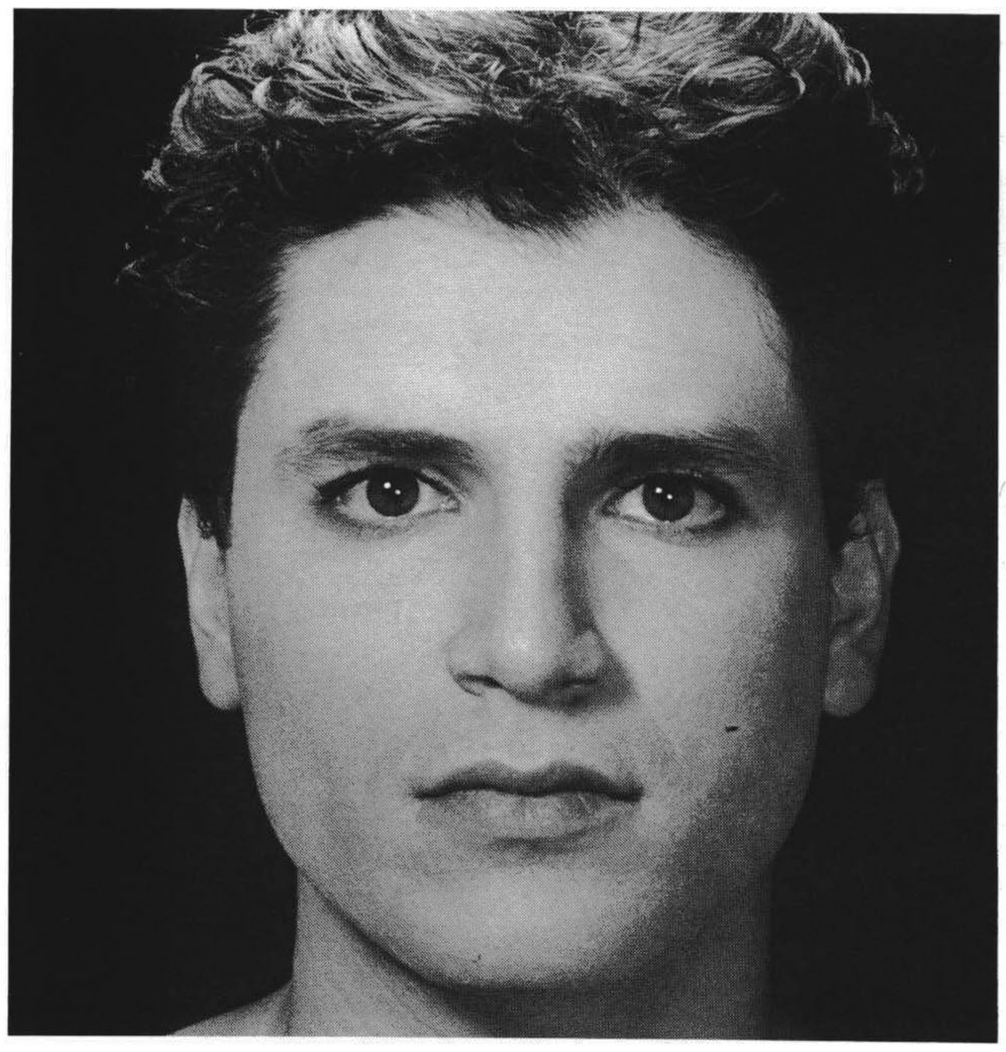


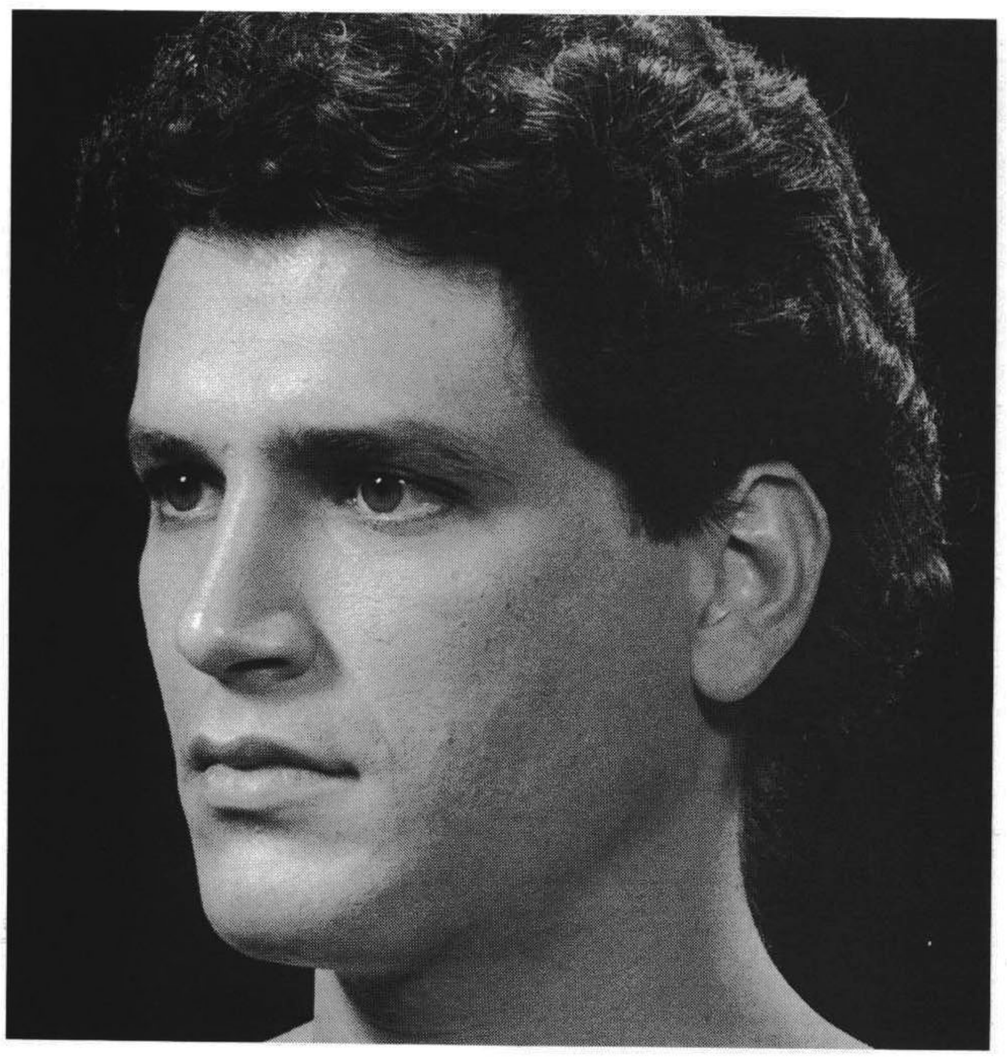
Simplified planes



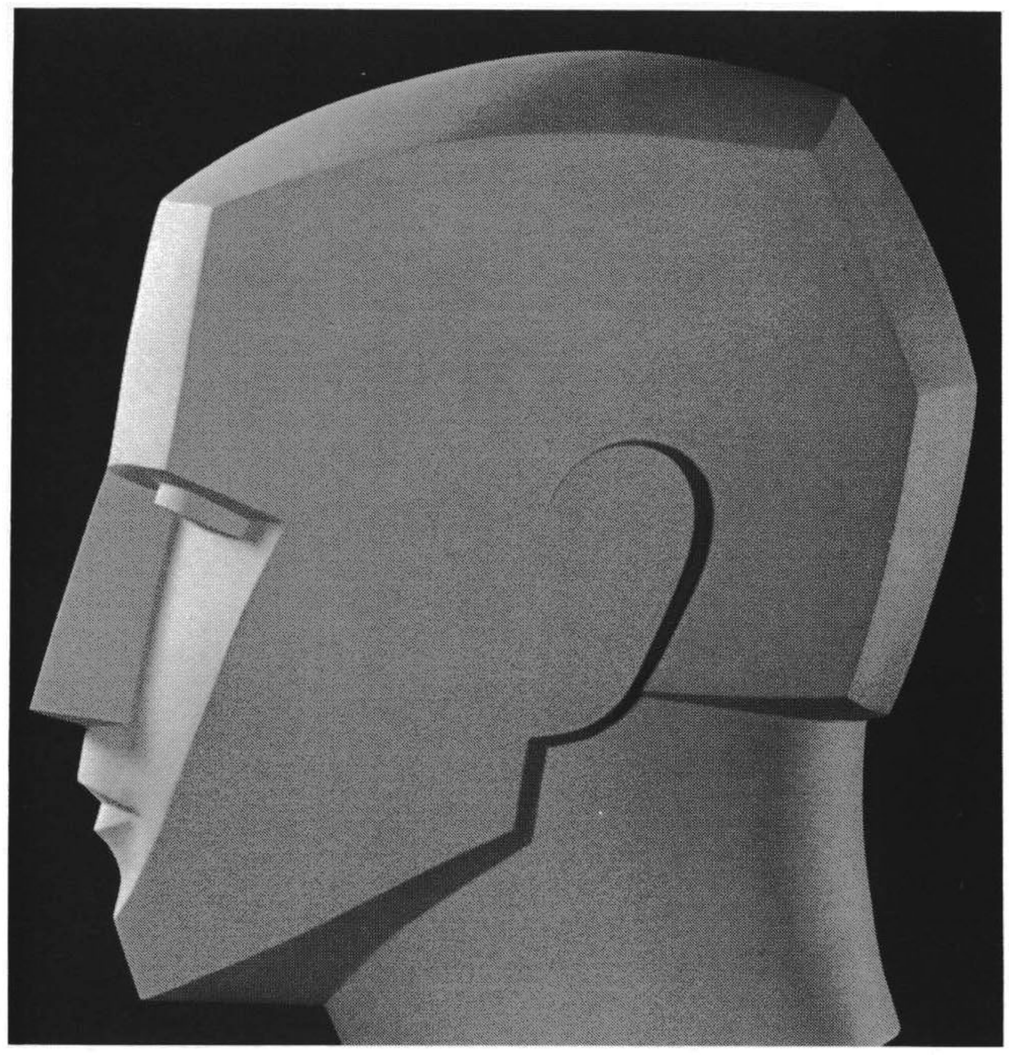


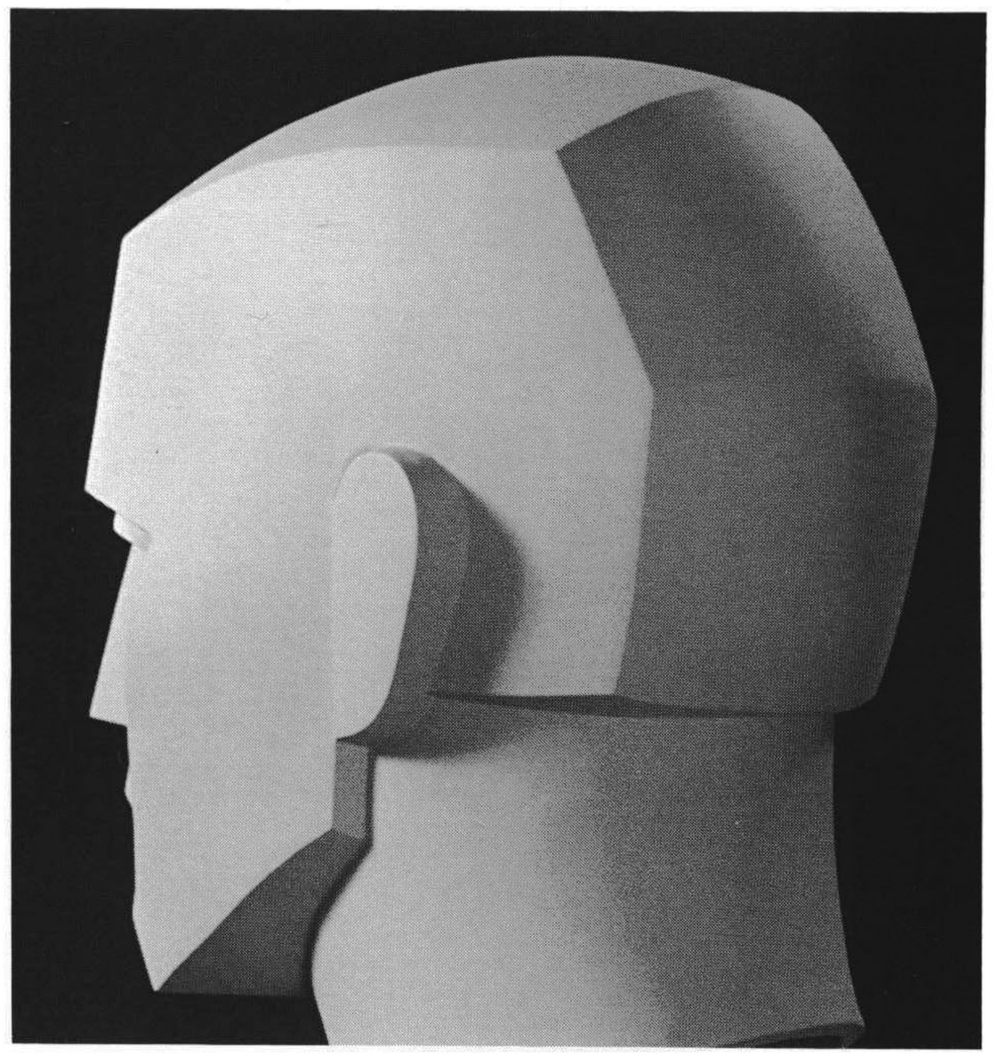
Male—life

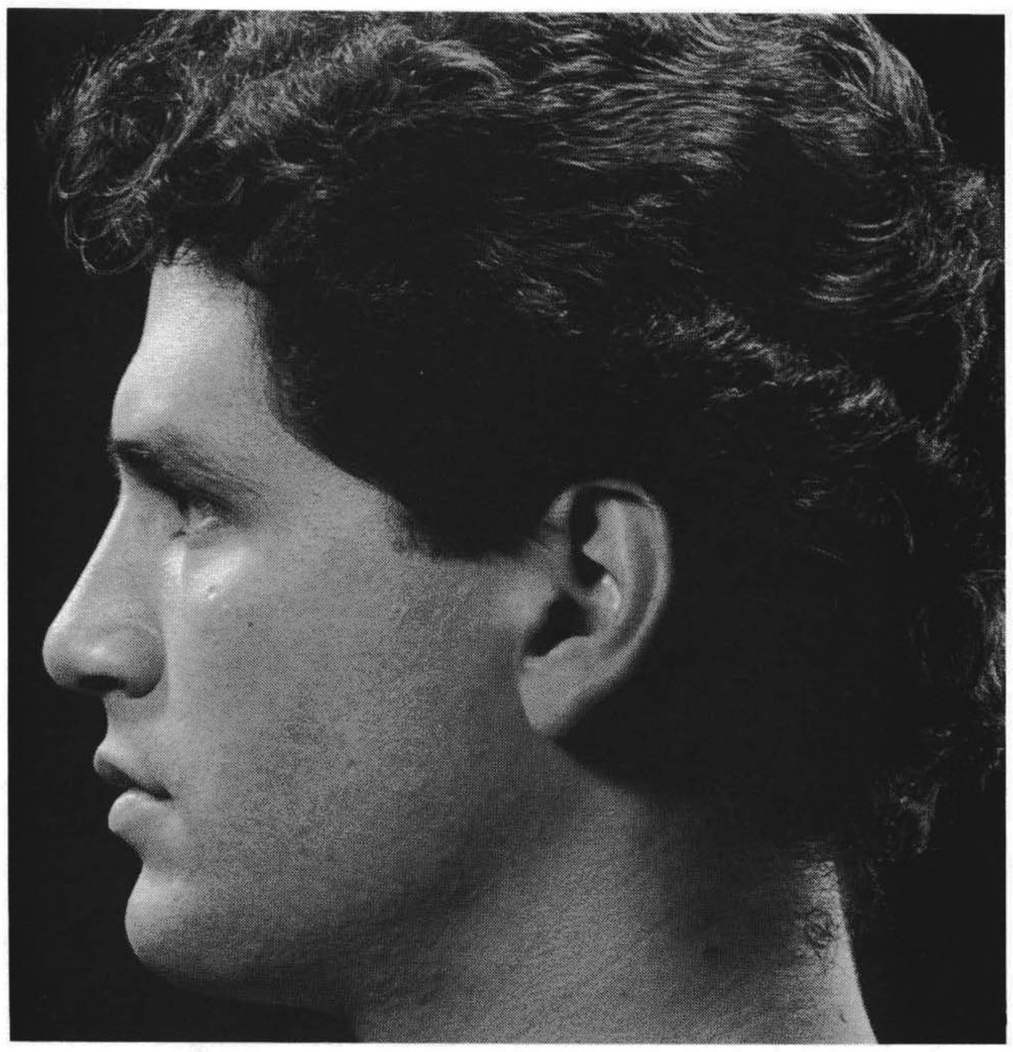


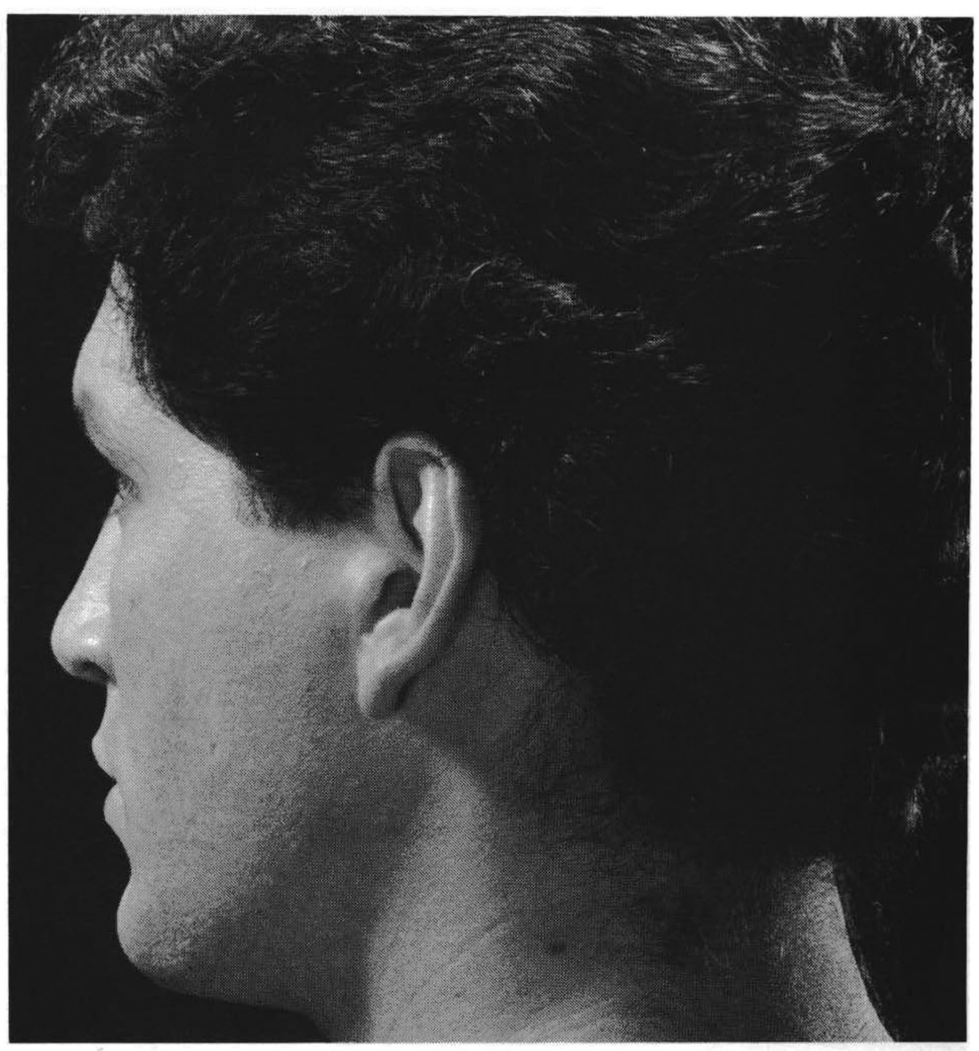


Mass Conceptions of the Head

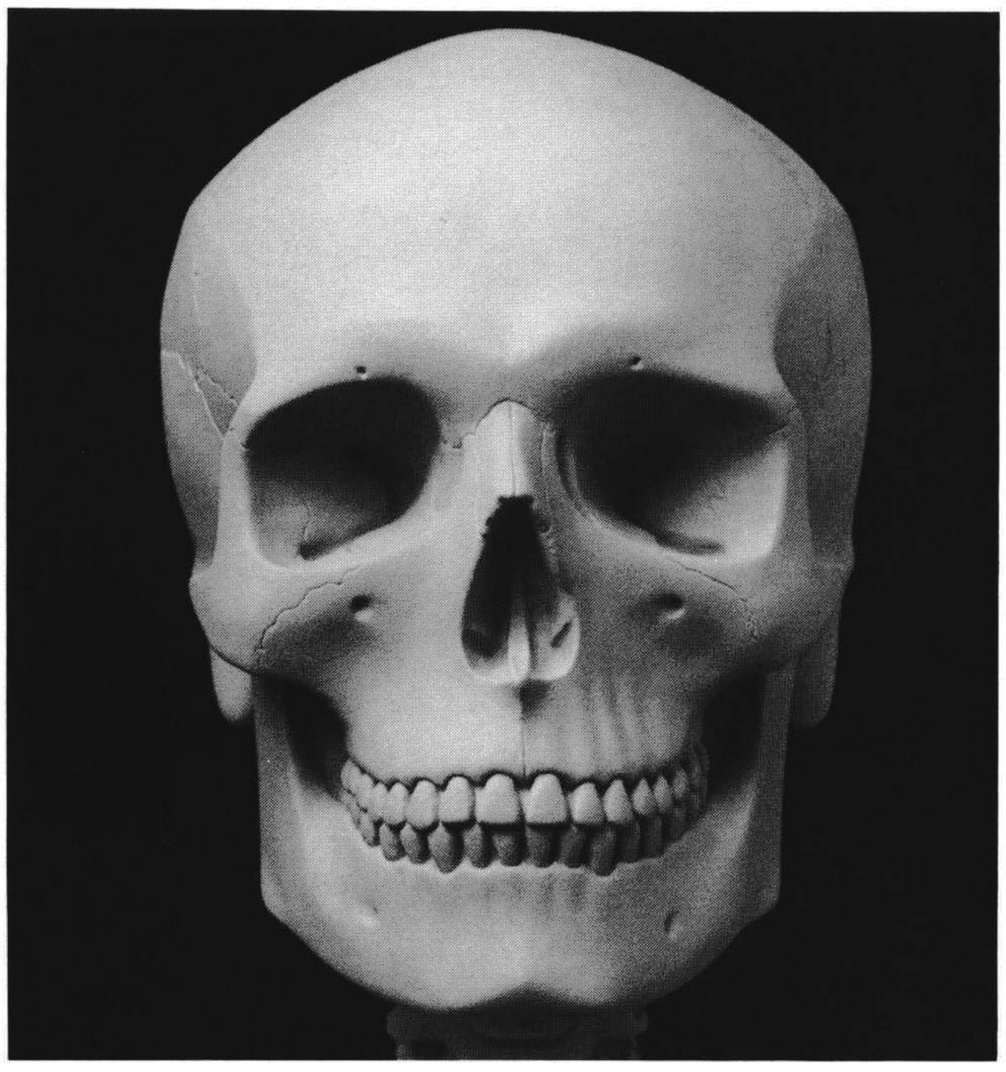


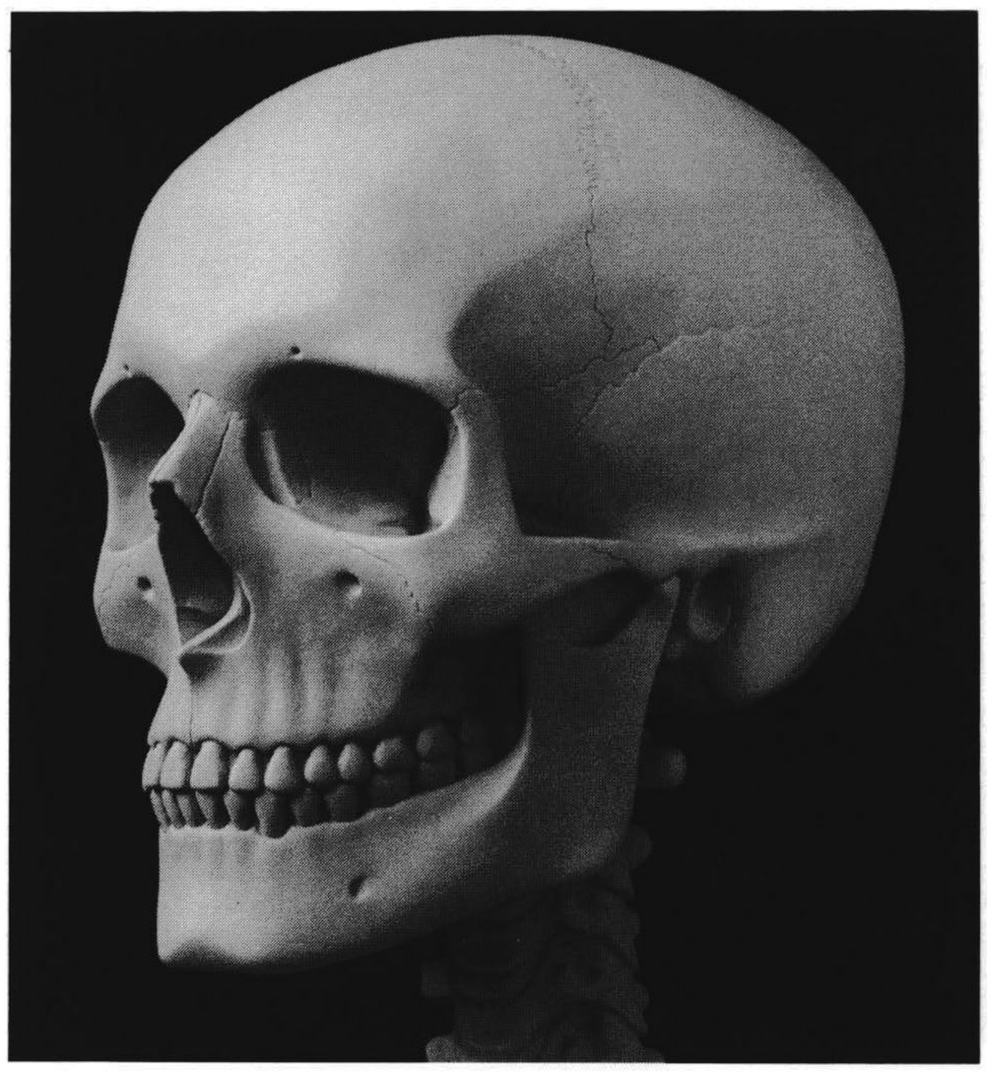




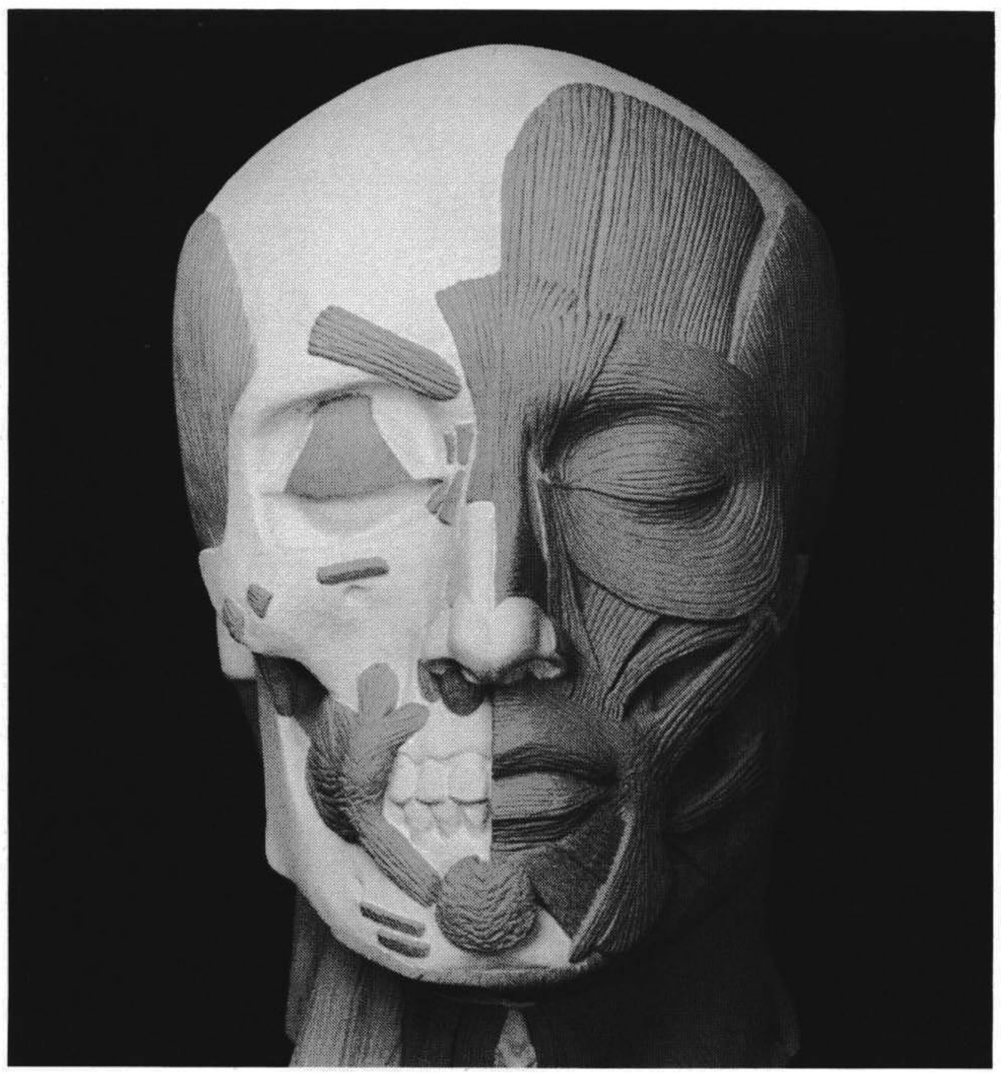


Skull

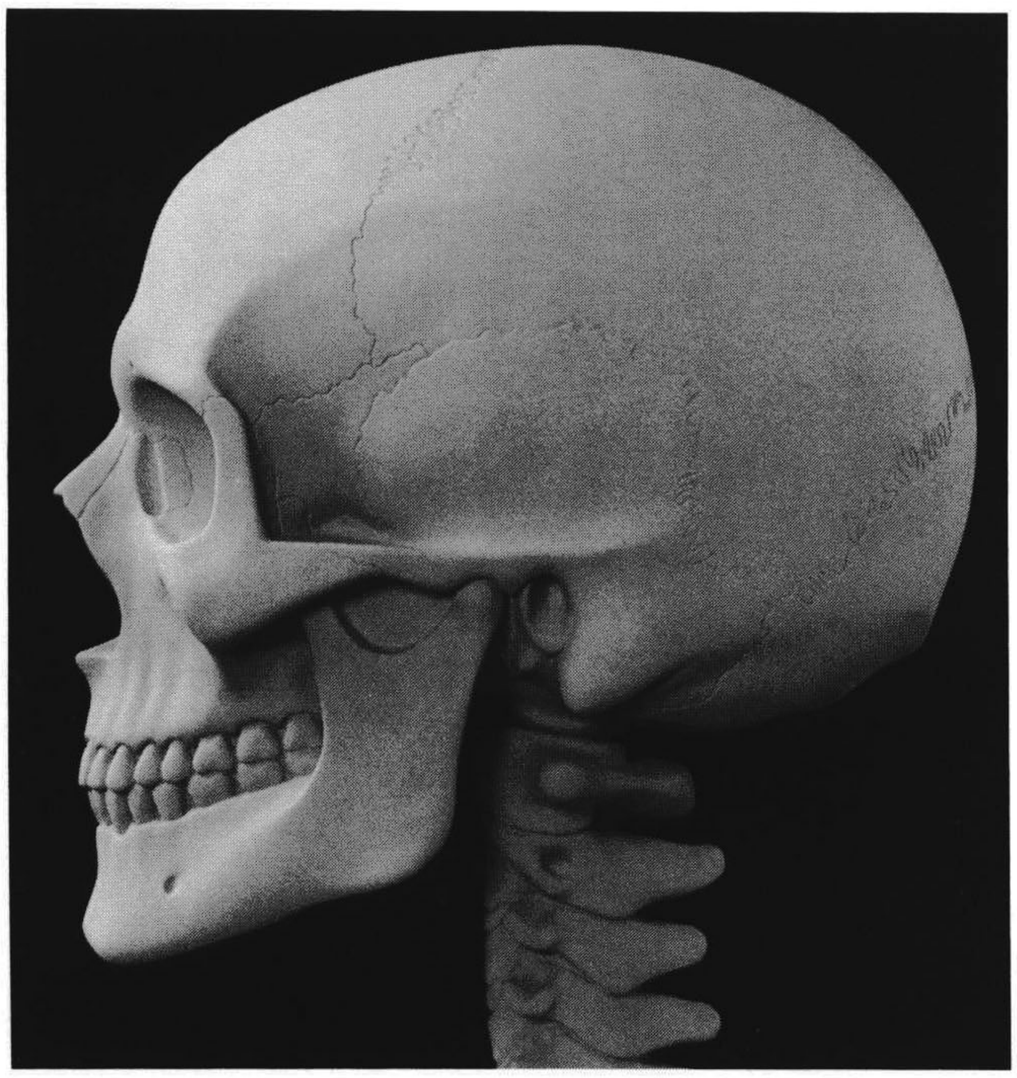


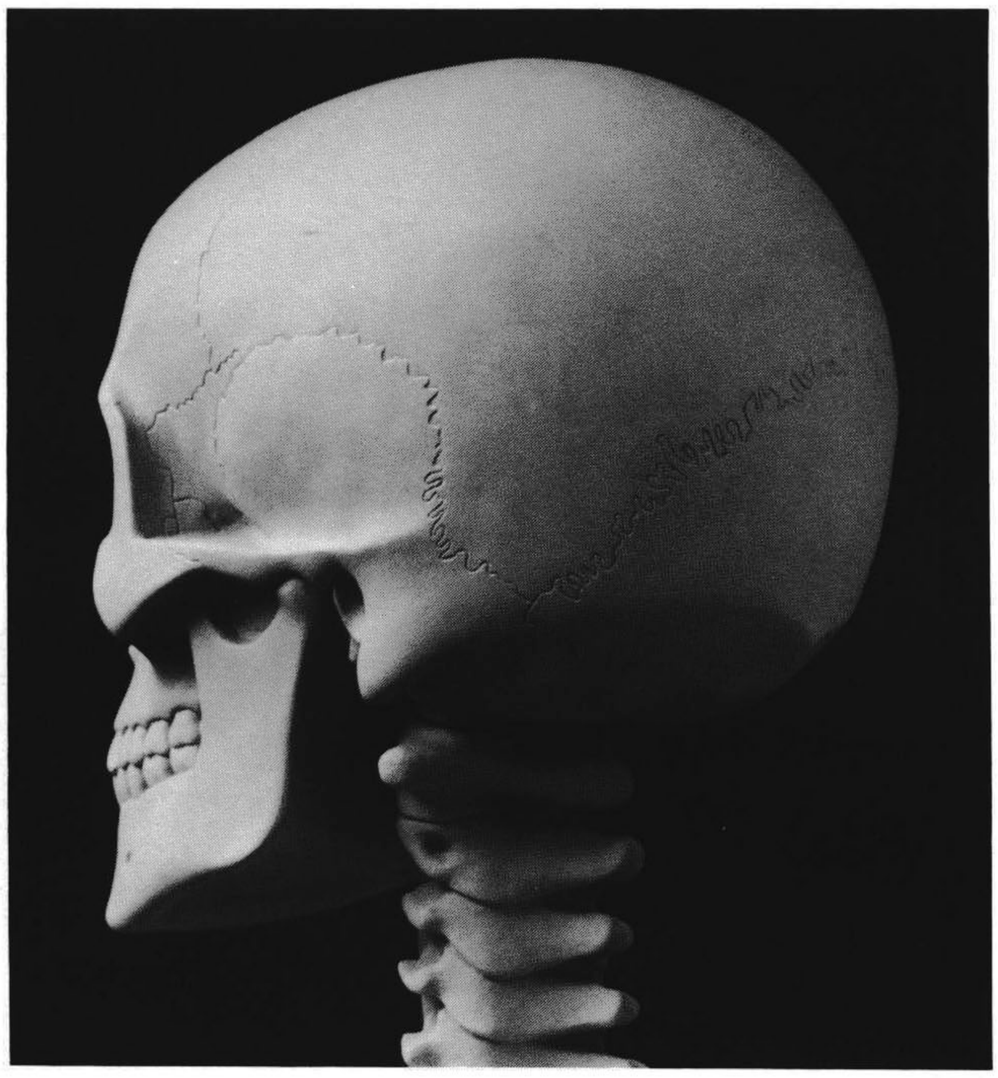


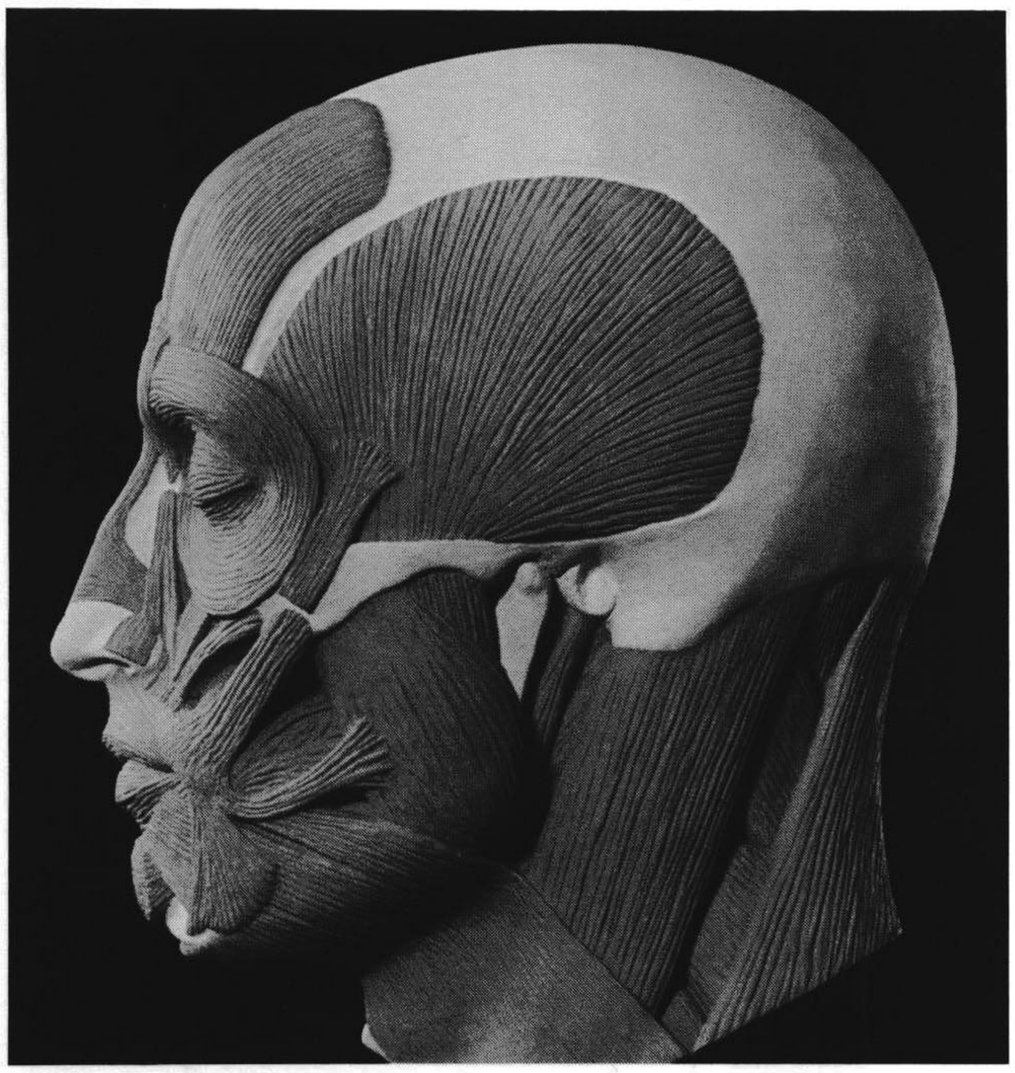
Muscles

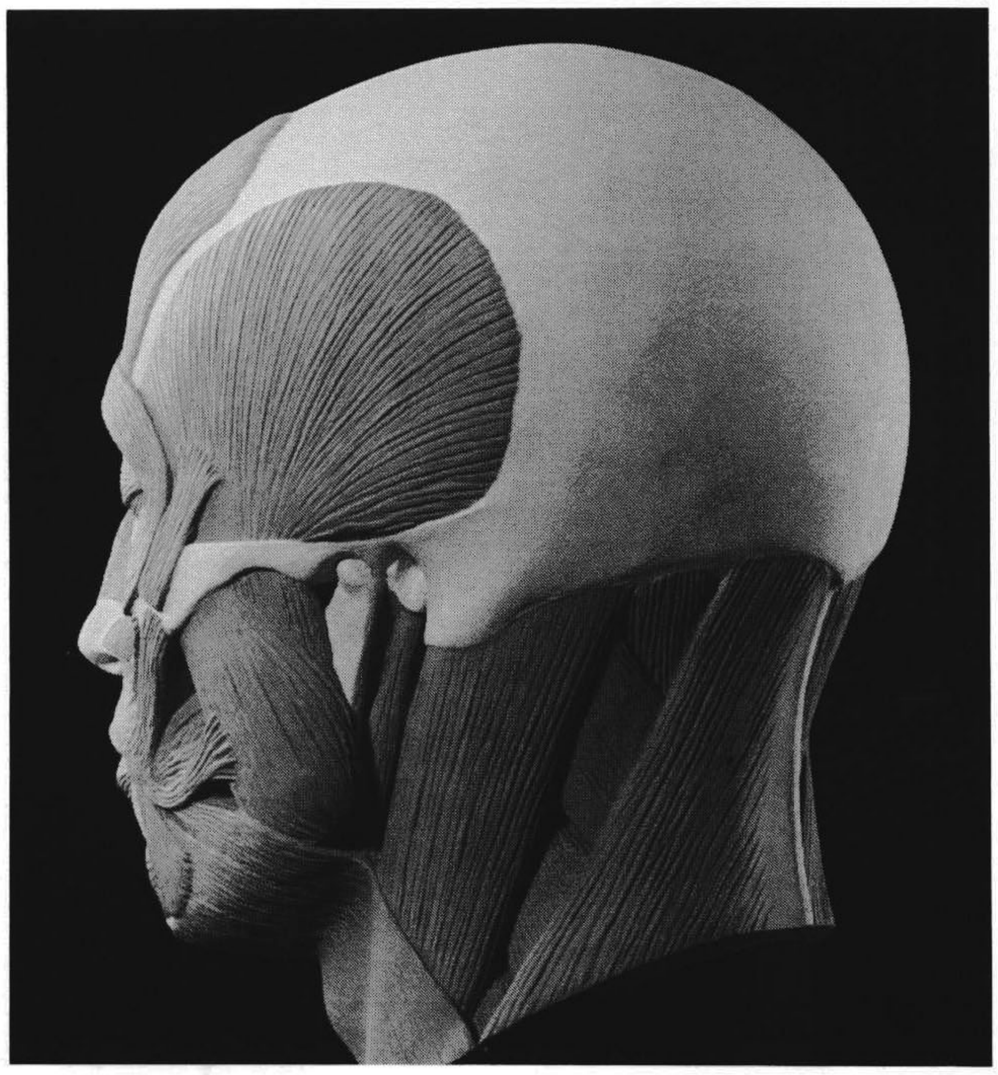


Mass Conceptions of the Head

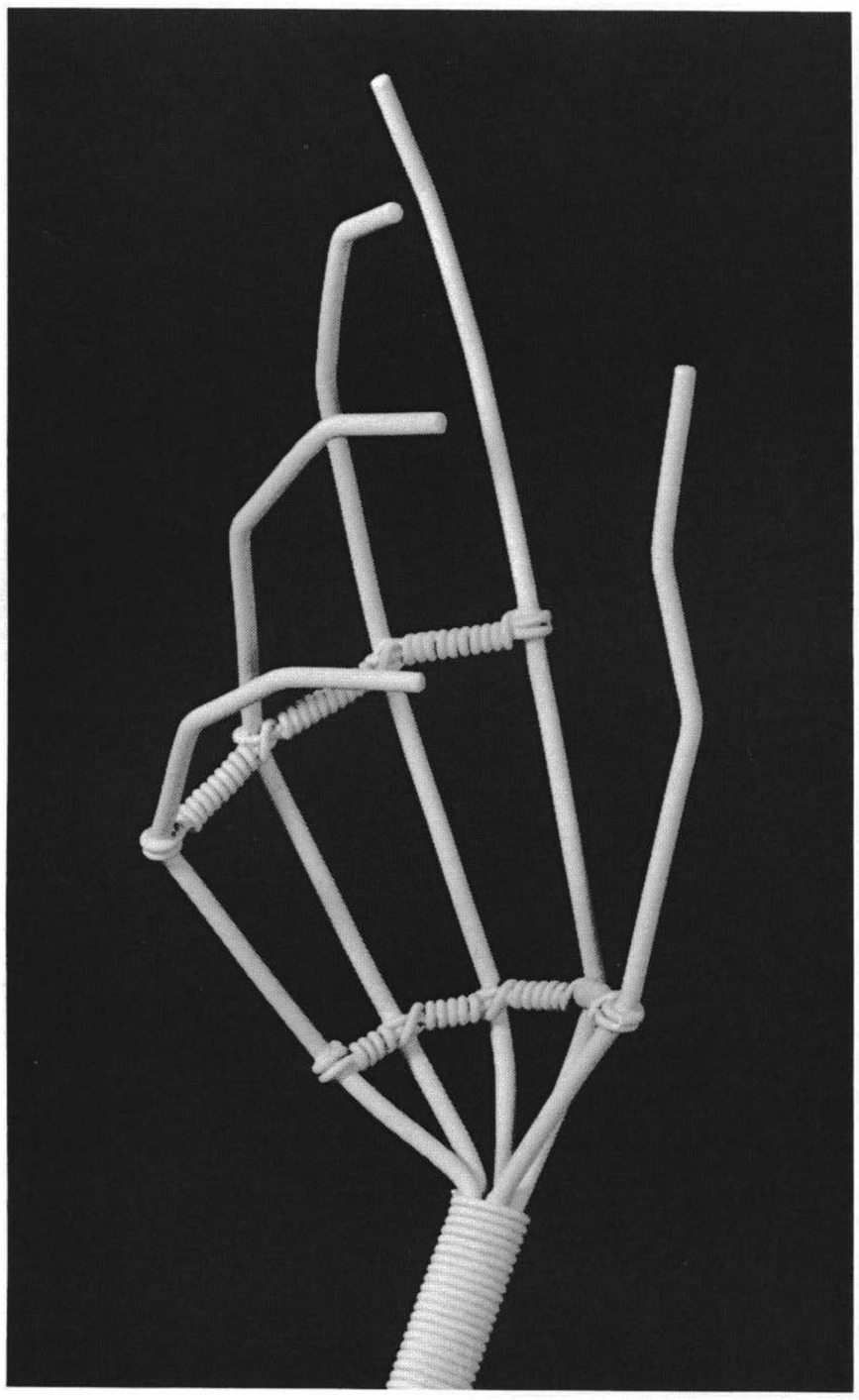


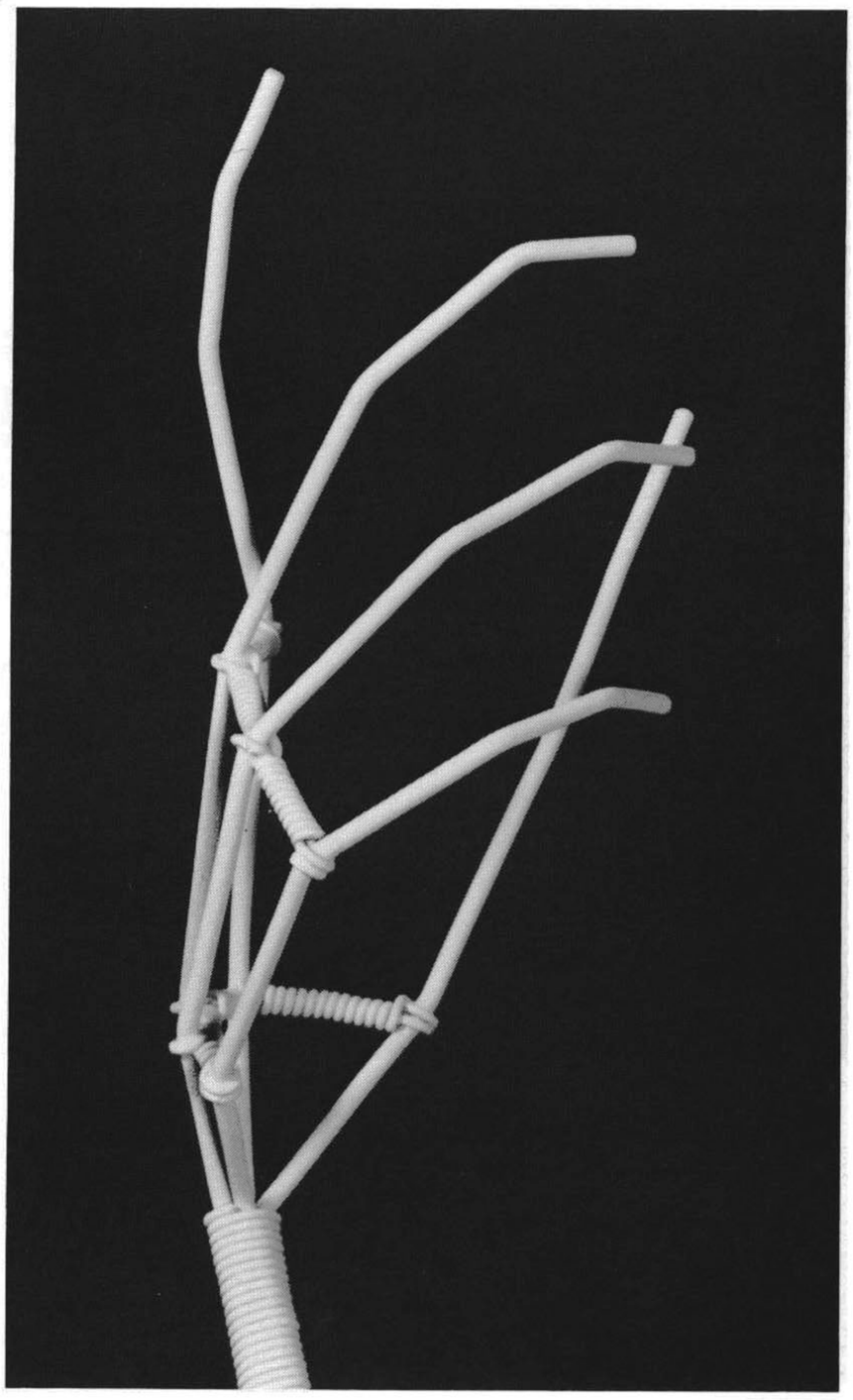






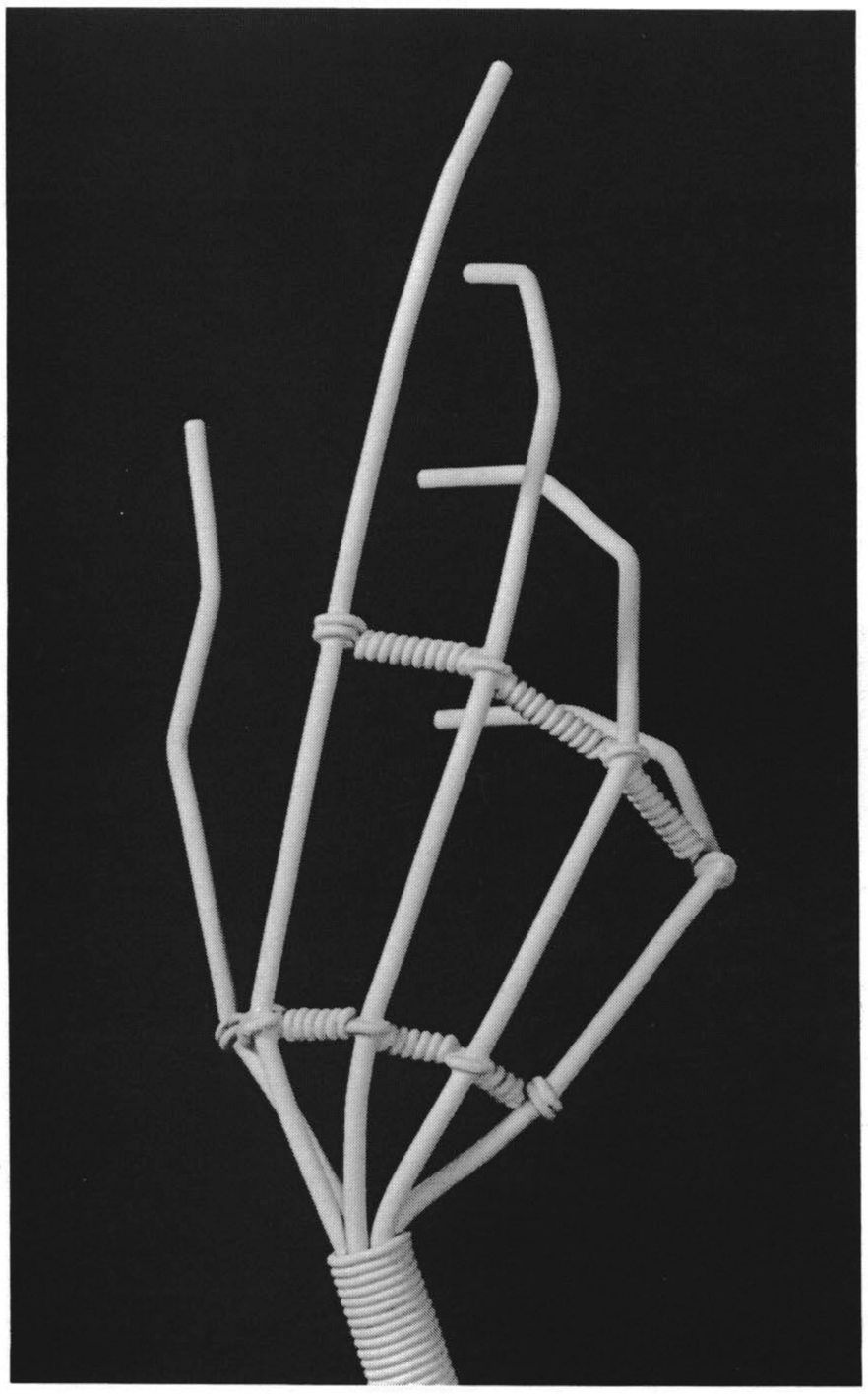
Axes

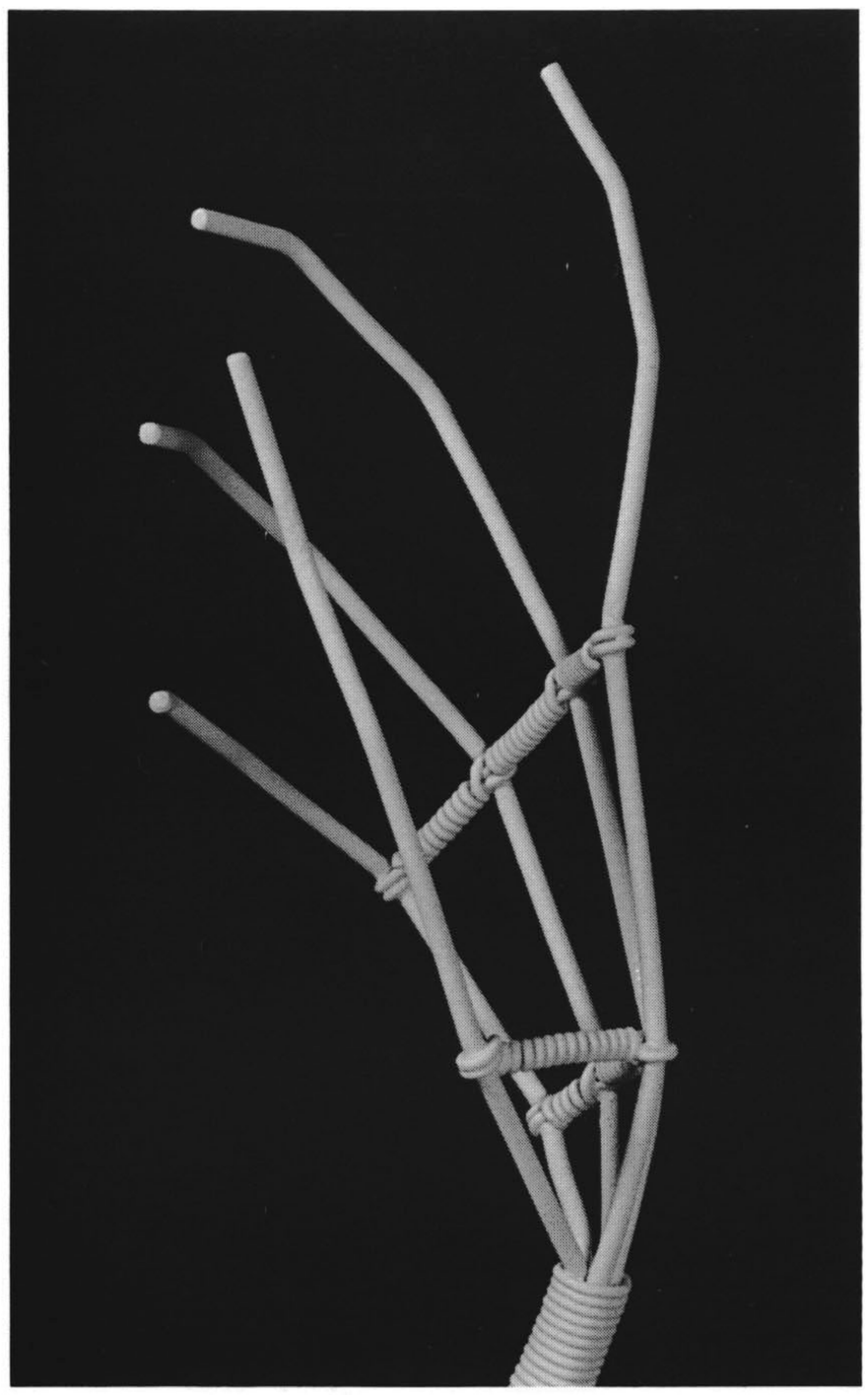




Skeleton
(actual bone)

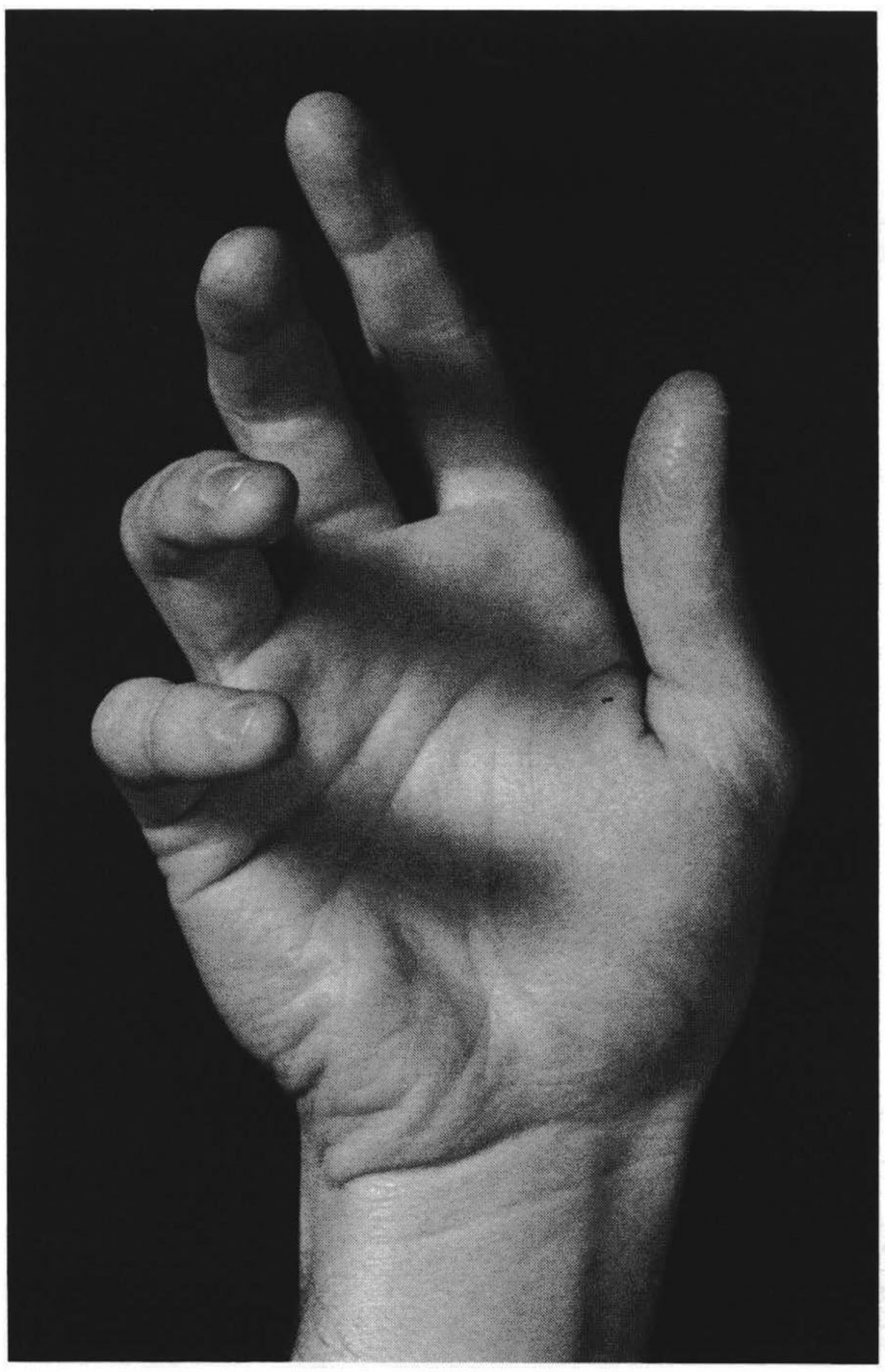
Mass Conceptions of the Hand

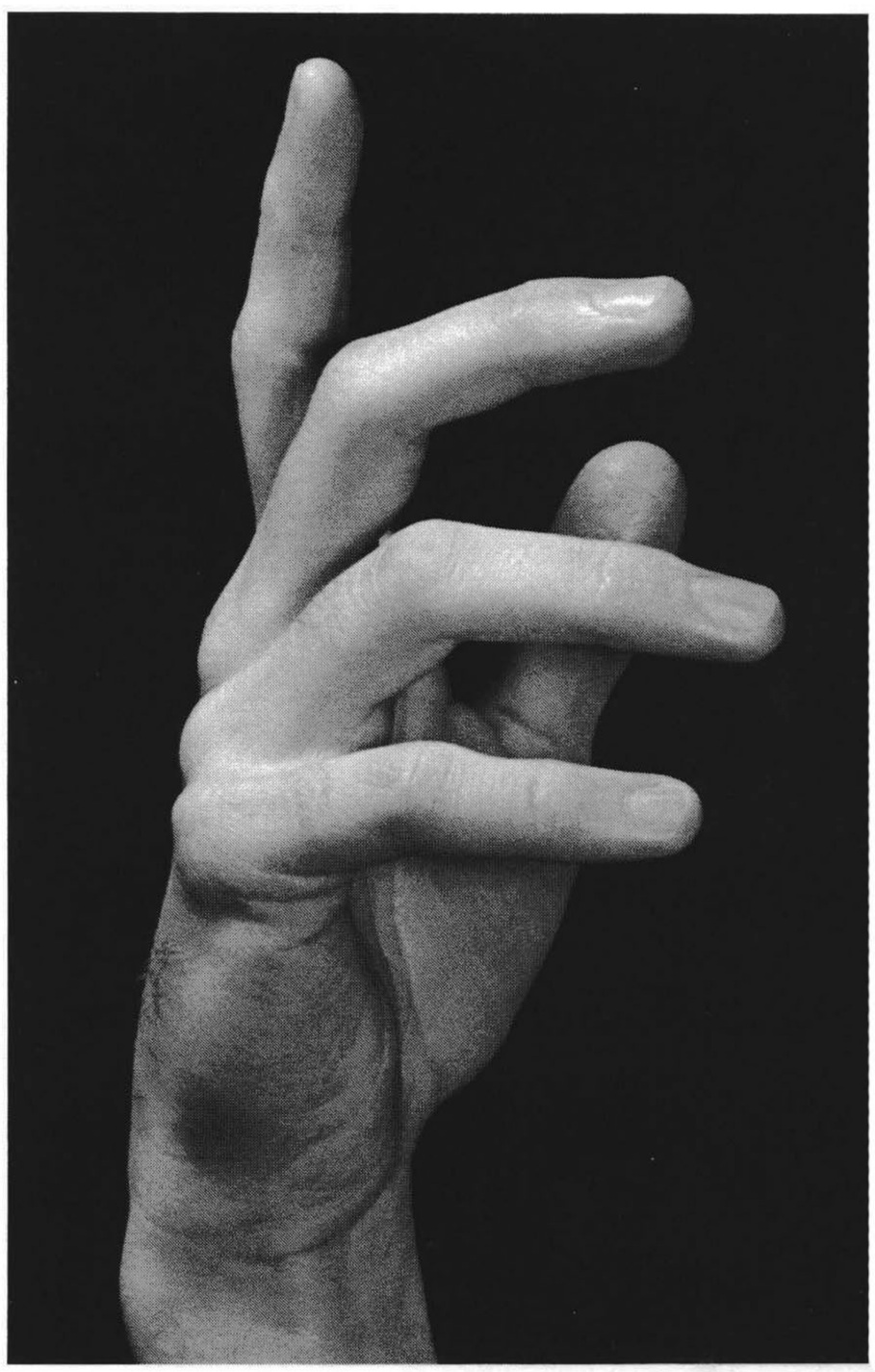




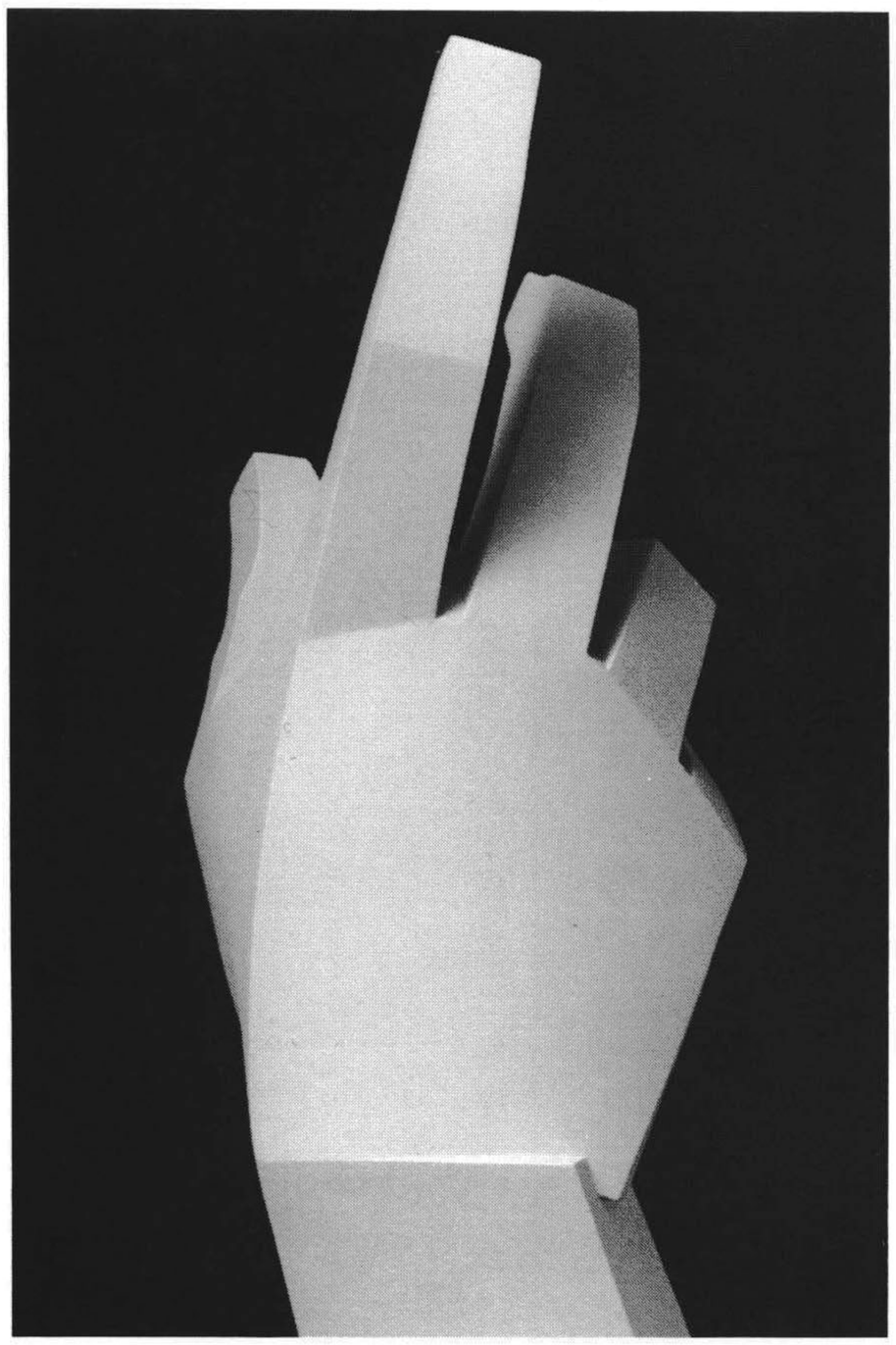
Blocks and planes

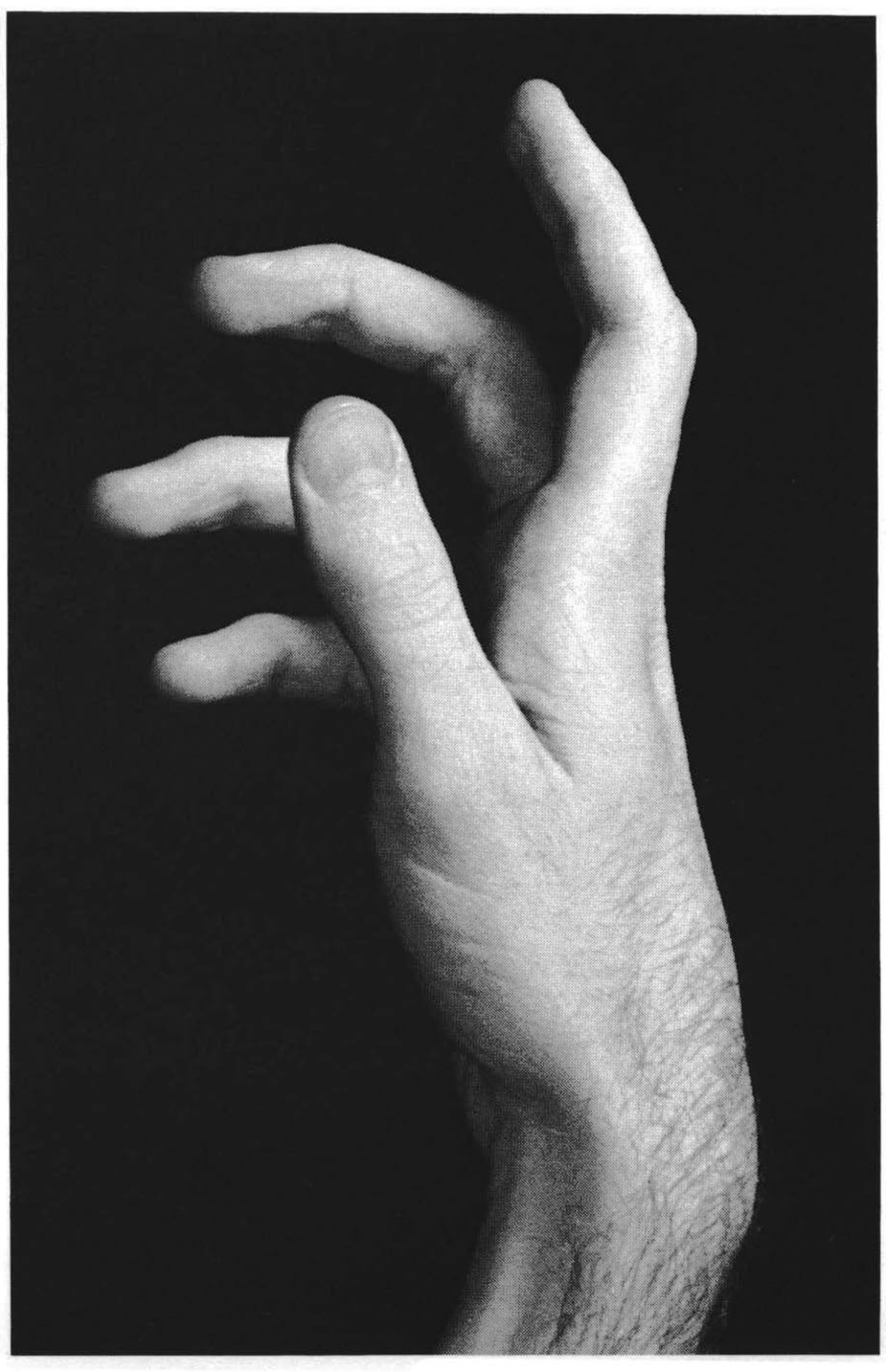
Male—life





Mass Conceptions of the Hand





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